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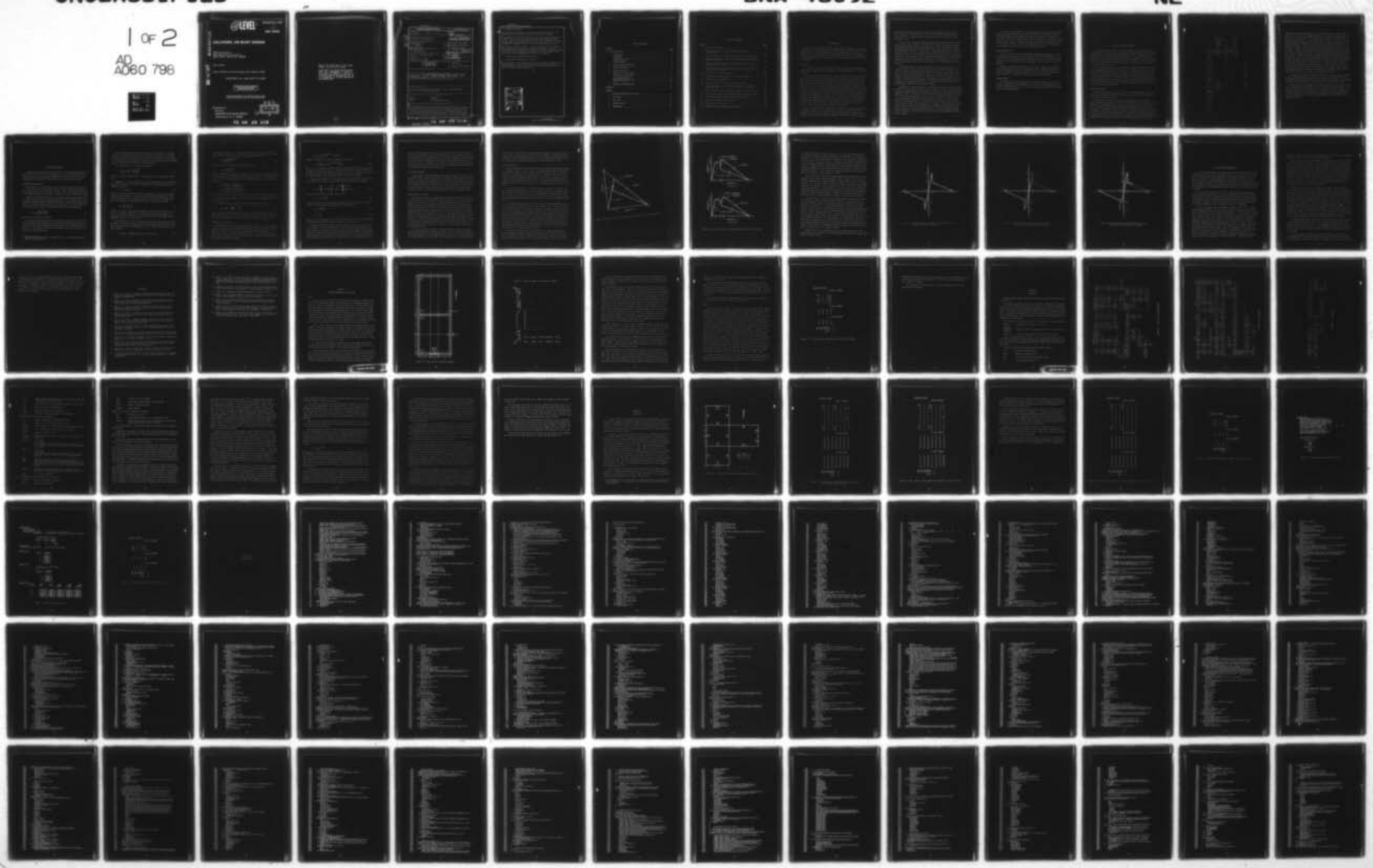

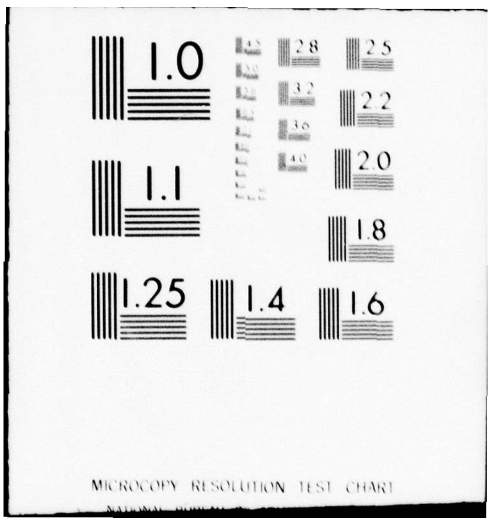
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COLLATERAL AIR BLAST DAMAGE

SRI International
333 Ravenswood Avenue
Menlo Park, California 94025

April 1978

Interim Report for Period May 1977—March 1978

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SRI International has been participating in a program to develop a collateral damage methodology for evaluating air blast damage to existing structures that would result from the use of tactical nuclear weapons in small towns and villages located in Western Europe. To increase the applicability of the SRI structural element computer programs for collateral damage predictions, a building subsystem program was developed. The program, BRACOB → next page

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20. ABSTRACT (Continued)

cont (Blast Response and Collapse of Buildings), simultaneously analyzes the response of all exterior walls on one story level of a building.

The program will calculate the separate responses of exterior unreinforced masonry walls to an air blast that sweeps over the building at normal incidence. The calculation is made in steps; each corresponds to a small time interval that begins when the blast front impacts the front face of the building; all subsequent events in the building are taken into account.

Three kinds of input are required: air blast description (e.g., peak free-field overpressure, weapon yield, and ambient conditions), floor plan information and wall structural properties (e.g., density, flexural strength, and in-plane vertical load). The program then traces the passage of the shock wave over the building at each time step, calculating:

- Net loading present against each wall,
- The resulting response of each wall.

The program detects wall collapse and, after each collapse, changes the floor plan accordingly. Calculation continues until either the blast wave has passed through the entire building or all of the walls have collapsed. The final floor plan is output in any case.

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I INTRODUCTION

Under contract to the Defense Nuclear Agency, SRI International is developing a methodology for evaluating collateral air blast damage to existing structures that results from the use of tactical nuclear weapons in small towns and villages in Western Europe. In the work covered in this report SRI developed a building subsystem computer program for the blast analysis of all exterior walls on one story level of a building.

BACKGROUND

For a number of years, SRI has been developing a relatively simple method for evaluating the dynamic response and collapse of existing buildings for civil defense purposes.[1-7]

When first developing the method of analysis for the dynamic response and collapse of structural elements, various analytical procedures were considered. Because of the many unknown factors involved in the dynamic analysis of actual buildings and because of the markedly nonlinear behavior of structural elements at the large deflections associated with collapse, the single-degree-of-freedom analogy was selected. To arrive at a realistic mathematical model with this method, it is first necessary to develop a resistance function that adequately predicts the load-deflection history of the member, and then to transform the actual structural member into an equivalent single-degree-of-freedom system. Experience in correlating the predictions of the mathematical models with test data has shown that the single-degree-of-freedom model can predict actual response with an accuracy to which the blast load and element characteristics of actual structures are known. The equation of motion is solved using the Newmark β numerical integration.[8]

During a previous phase of the program, considerable information on the details of building construction in West Germany was collected, and two major classes of buildings were identified as typical of small villages--masonry load-bearing wall buildings and half-timber or Fachwerk buildings. Using the SRI building evaluation

procedure with a modified air blast routine, collapse analyses for the exterior walls and floors over basements for an older type and a modern type German house were performed for a range of weapon yields from 0.1 kt to 1 Mt (.4184 to 4184 terajoules or TJ).

As part of the collateral building program, SRI participated in the Dice Throw event at White Sands, New Mexico, in October 1976. Based on the German building data gathered previously and on consultations with a West German-trained architect, SRI designed three identical test structures. The design consisted of two adjoining, but distinct, test cells constructed on a common reinforced concrete slab cast on grade; one test cell was of masonry wall construction and the other of Fachwerk construction. The structures were located at three ground ranges. The SRI computer programs were used for analyzing the structures, for locating them in the field test, for providing predictions of preshot damage, and for performing the postshot analysis.[9]

The building element computer programs previously developed by SRI were intended as research tools for use in developing realistic analytical models to predict the collapse of building elements under blast loading. Because of the complexity of analyzing the response and collapse of an entire building under dynamic loading, as well as the difficulty of calculating precise blast loadings on each element in a complex building geometry, the approach at that time was not to develop a complete building system but was rather to establish a sound technical basis for the mathematical model for each structural element.

Although SRI's original intent was to incorporate subroutines for each building element into a single building system computer program, the need to analyze existing buildings preempted completion of that program. Therefore, in the research studies summarized in Refs. 1 through 7, relatively complete computer programs were prepared for each building element; thus, for each type of wall and floor element the computer code provides a main routine and subroutines to calculate: the resistance function, transformation factors, the exterior and interior blast pressure and the net load on the element, and the probability of collapse. These individual programs permitted analyses of existing buildings to be performed much sooner than would otherwise have been possible, and the availability of individual element programs proved convenient in correlating analytical predictions with experimental data for specific elements.

To increase the applicability of these programs in predicting collateral blast damage, a building subsystem program has been developed in the current research. The program, BRACOB (Blast Response and Collapse of Buildings), simultaneously analyzes the response of all exterior walls on one story level of a building. The initial program is limited to unreinforced masonry walls without arching and to blast waves at normal incidence. However, the program provides for later modifications to accept other types of walls, as well as oblique blast waves.

REPORT ORGANIZATION

Section II briefly describes the building subsystem program BRACOB. Section III describes the physical principles involved in the subsystem program; i.e., the interaction of the blast wave with the building, the flow of air into the building openings and the resulting interior wall loadings, and the response of the wall elements.

Appendices supplement the main body of the report. Appendix A describes the input requirements and output of the program in detail. A program flow chart is presented in Appendix B, and the results of the test cases thus far analyzed are given in Appendix C. Appendix D contains a complete program listing.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the assistance and guidance of Mr. T. E. Kennedy of Headquarters, DNA, throughout this research. Also acknowledged are the helpful suggestions given by Mr. J. E. Beck of SRI International during the development of the computer program.

II BUILDING SUBSYSTEM PROGRAM

To enable the rapid estimate of collateral damage to an entire structure by air blast, SRI is currently developing a computer program to apply the SRI building element analyses to one story of a whole building. Such a program must not only keep track of the simultaneous loading and response of a number of elements, it must also provide for effects resulting from interactions among the elements. The failure of a wall element may, for example, change the subsequent air blast loading on a second wall or floor element.

SRI's building element analyses are individual computer programs that calculate the time-dependent response up to collapse of various types of wall and floor elements to arbitrary blast loading.[1-7] Eventually, a computerized building system program will combine into one program the analyses of all the elements in a multistory building subjected to an air blast loading. Work to date has produced a running program that analyzes the dynamic response of unreinforced masonry walls on one story of a building struck by an air blast moving perpendicularly to one of the exterior walls (at normal incidence).

PROGRAM DESCRIPTION

For all exterior walls on one floor level of a building BRACOB will calculate the separate responses that take place as the result of an air blast sweeping over the building at normal incidence.

The calculation is made in steps, each corresponding to a small interval of time, beginning at the moment of impact of the blast front and the front face of the building. All subsequent events at each wall in the building are taken into account. Operation of the program can be understood from the simplified flow chart in Figure 1. Three kinds of input are required: air blast description, floor plan description, and wall structural properties (e.g., density, flexural strength, and in-plane vertical load). For use during the response calculations, the program then organizes this information into matrix form by identifying walls and rooms and

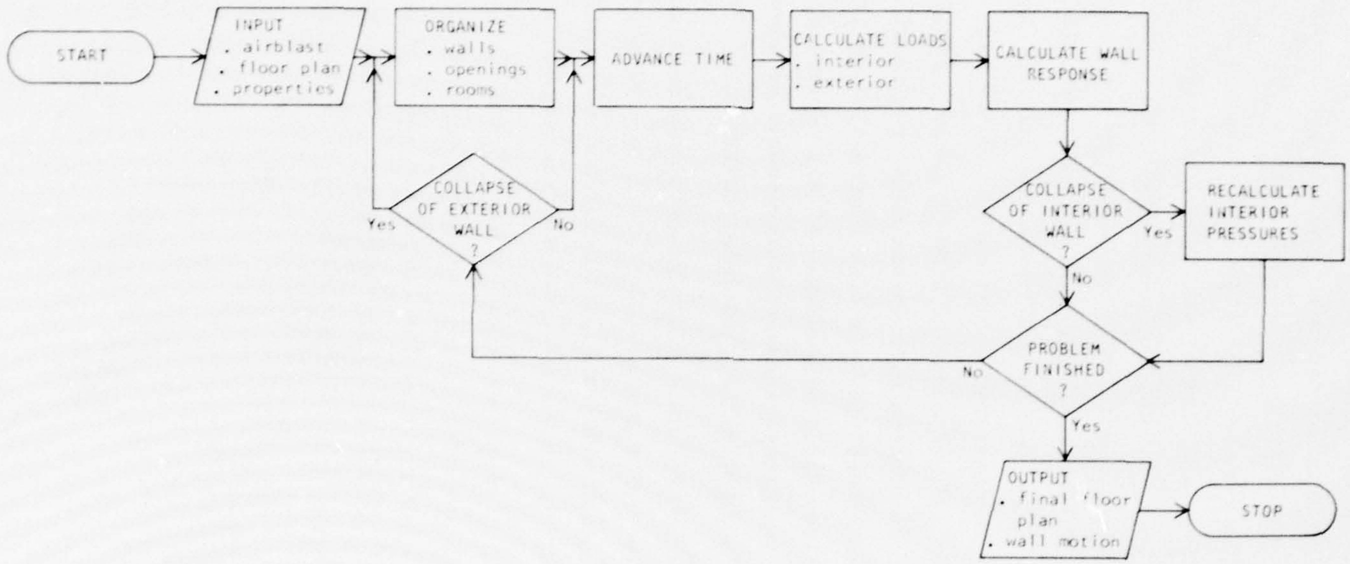

Figure 1. Simplified flow chart.

correlating walls and openings with the rooms in which they are located. When organization is complete, the program enters the time loop where it remains until one of three events takes place: (1) an outside wall collapses, (2) the blast wave passes over the building, or (3) all walls collapse. Within the time loop, current exterior and interior pressures on each wall are calculated, and exterior wall responses (acceleration, velocity, and deflection) are calculated; each wall is then tested for collapse. At present, interior wall collapse can, if desired, be preset by the user to occur at specified times; interior wall responses are not currently calculated. As suggested in Figure 1, interior wall removal requires some reorganization aimed at correcting some of the interior pressures exerted against interior wall surfaces. The test for problem completion follows. When exit from the program is made, the final floor plan and, if desired, room pressures, wall displacements, and velocities are printed. If program exit is not made, the final test before reentry of the time loop (shown by decision box A in Figure 1) asks if an exterior wall has failed during the time step just ending. If so, control must be passed to the organizing areas of the program to reassemble the remaining elements into new rooms, and only after this is done is the time loop reentered.

The form of input required to define floor geometry has been chosen to minimize a user's preliminary analysis. Geometry of the floor is established solely by a user-supplied, flexible grid with every wall terminus and each edge of every opening and every pilaster located at the intersection of two rectangular grid lines.

More detailed input requirements and further description of the output will be found in Appendix A, which should suffice for the operation of the program. A user wishing to learn more of the structure of the program is referred to Appendix B, "Flow Chart"; the test cases are described in Appendix C; and the program listing is given in Appendix D. The physical approximations used in the analysis are explained in Section III.

III PHYSICAL PRINCIPLES

BRACOB treats three kinds of physical events: the interaction between the air blast and the exterior walls of the building; the flow of air through openings in exterior walls, with the subsequent loading on the interior surfaces to all wall elements; and the response of the exterior walls to the applied net loading.

EXTERIOR AIR BLAST LOADING

Procedures used in calculating the exterior air blast loads are described in Ref. 10. Currently, the program accepts only one blast orientation with respect to the building, namely head-on or normal incidence. Thus, only three different kinds of wall-blast interactions occur--those of forward- , rear-, and side-facing walls.

Against all exterior wall surfaces a relatively short-lasting, transient pressure phase occurs, followed by a longer-lasting, more or less steady pressure. The transient overpressure against forward-facing walls is the peak reflected overpressure p_r which erodes linearly during the clearing time t_c* to the quasisteady pressure; p_r is directly related to the peak free-field side-on overpressure p_{so}

$$p_r = 2p_{so}\left(\frac{7p_o + 4p_{so}}{7p_o + p_{so}}\right) \tag{1}$$

where, p_o is the ambient air pressure.

The pressure-time history against rear-facing walls consists of a finite rise-time after arrival and diffraction of the shock front around the sides and top of the wall; the rise-time is assumed to increase linearly to a maximum value in the time 1.3 t_c. The duration of the back face loading is equal to the duration t_o of the positive overpressure phase.

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* Currently the user must furnish as input values of t_c for each exterior front-facing or rear-facing wall.

The transient pressure against side-facing walls also consists of a finite rise-time to a maximum value in a time equal to the travel time L/U of the shock front at velocity U down the length L of the wall. The rise-time of the loading on side-facing walls is assumed to be linear, with the duration of exterior loading equal to the duration of the positive overpressure phase.

The shock velocity U is found from the formula:

$$U = \left[1.4\ RT\left(1 + \frac{6p_{so}}{7p_o}\right)\right]^{0.5} \tag{2}$$

where, R is the gas constant, and T is the absolute value of the ambient temperature.

Regardless of the wall orientation, the quasisteady pressure p exerted against the exterior surface of the wall after completion of the transient phase can be expressed as the sum:

$$p = p_s + C_d p_d \ . \tag{3}$$

That is, the sum of the free-field side-on overpressure p_s and the drag pressure expressed as the product of a drag coefficient C_d and dynamic pressure p_d. The drag coefficient differs for each wall orientation, and on side- and rear-facing walls it is negative. The dynamic pressure p_d is found from the formula:

$$p_d = \frac{5}{2}\left(\frac{p_s^2}{7p_o + p_s}\right) \tag{4}$$

Strictly, the side-on overpressure and dynamic pressure decrease slightly as a result of the distance required for the shock front to traverse the length of the buildings. However, this effect is generally small for actual buildings when the weapon yield is 4 TJ ($\sim$ 1 kt) or more.

Only the variation in time of the side-on overpressure behind the shock front p_s remains to be defined. The program determines the wave shape from built-in factors, the peak free-field overpressure p_{so}, and the positive phase duration of the overpressure t_o:

$$p_s = p_{so}\left(1 - \frac{t}{t_o}\right)\left(a\ \exp(-\alpha t/t_o) + b\ \exp(-\beta t/t_o)\right) \tag{5}$$

Positive phase duration t_o is found as a function of peak side-on overpressure p_{so} from an empirical curve-fit to the 1 kt data presented in Ref. 11:

$$t_{o1} = \left(\frac{1.8478}{p_{so}}\right)^{0.39429} \tag{6}$$

which is scaled in the usual way to arbitrary yield W:

$$t_o = t_{o1}\left(\frac{W}{4.184}\right)^{1/3} \tag{7}$$

In these formulas p_{so} is measured in kilopascals (kPa), W in TJ, and time in seconds (s); the formulas are valid only over the range $p_{so} < 345$ kPa. The form factors a, b, α, and β are pressure-dependent, and in the pressure range $p_{so} < 345$ kPa can be written as:

$$a = 0.932659 - 0.00118936\ p_{so}$$
$$b = 0.0735423 + 0.00121053\ p_{so}$$
$$\alpha = -0.620996 + 0.335668 \ln p_{so}$$
$$\beta = -1.32000 + 1.68236 \ln p_{so}\ .$$

These factors were derived from a curve fit to wave shapes published in Ref. 10.

A negative pressure phase is not included in the present program; therefore for times $t \geq t_o$, $p_s = 0$.

Dynamic pressure p_d is assumed to decay according to the equation

$$p_d = p_{do}\left(1 - \frac{t}{t_u}\right)^2 \left(e^{-2t/t_u}\right) \tag{8}$$

and no distinction is made between the duration of the positive phase of the dynamic pressure t_u and that of the side-on overpressure phase t_o (see Ref. 10), i.e., t_u in Eq. 8 is assumed to be equal to t_o in Eq. 5. Thus for $t \geq t_u$, $p_d = 0$.

INTERIOR AIR BLAST LOADING

Interior pressures exerted against the interior surfaces of all wall elements result from the high-pressure inflow through openings in the exterior walls of the building. Calculation of this inflow follows a pattern described in Ref. 12. If the ratio of interior to exterior pressure is below a critical value, i.e., $p_3/p_1 < p_{crit}$, where p_3 and p_1 are total or absolute values of pressure inside and outside the opening, respectively, and where

$$p_{crit} = \left(\frac{2}{\gamma + 1}\right)^{\gamma/(\gamma-1)} = 0.5283 \ , \tag{9}$$

inflow is "choked" and the mass increment ΔM in the room is

$$\Delta M = K \left[\rho_1 p_1 \gamma \left(\frac{2}{\gamma + 1}\right)^{(\gamma+1)/(\gamma-1)}\right]^{\frac{1}{2}} A_w \Delta t \ . \tag{10}$$

Here $\gamma = 7/5$ is the ratio of specific heat at constant pressure to the specific heat at constant volume for air and K is a discharge coefficient; ρ_1 and p_1 are outside air density and (absolute) pressure, respectively; A_w is the opening area and Δt is the time increment. Area A_w and coefficient K are required as input.

As the inside pressure p_3 rises toward the outside pressure the critical ratio is exceeded; that is, $p_3/p_1 > p_{crit}$ and the inflow is found from the formula

$$\Delta M = K\rho_1 \left\{ 2\left(\frac{\gamma}{\gamma - 1}\right)\left(\frac{p_1}{\rho_1}\right)\left[1 - \left(\frac{p_3}{p_1}\right)^{\left(\frac{\gamma}{\gamma-1}\right)}\right]\right\}^{\frac{1}{2}} \left(\frac{p_3}{p_1}\right)^{\left(\frac{1}{\gamma}\right)} A_w \Delta t \tag{11}$$

In both cases the energy increment in the room is

$$\Delta W = \frac{\gamma}{\gamma - 1} p_1 \frac{\Delta M}{\rho_1} \tag{12}$$

At each time, mass and energy increments stemming from each opening in a room are summed to provide updated pressure and density in that room:

$$\Delta p_3 = \frac{\Delta W(\gamma - 1)}{V_R} \tag{13}$$

$$\Delta \rho_3 = \frac{\Delta M}{V_R} \tag{14}$$

where V_R is the room volume. The net load on an outside wall is then the difference between exterior and interior pressures times the net wall area.

Although inflow begins through an outside opening as soon after blast arrival as the opening cover (i.e., window glass or door) has cleared the opening, the interior pressure is not applied to the outside wall of the room until a backloading time delay, characteristic of each wall, has been satisfied. This delay is the time between the arrival of the blast at the exterior face of the wall and initiation of pressure against the interior surface of the same wall; it is assumed equal to the

sum of or difference between the travel times of the exterior and interior shocks from an outside opening to the wall (net travel time). In calculating this delay, the program finds the net travel times from all outside openings in the room to the wall, and selects the minimum, which then becomes the backloading time delay for that exterior wall. For simplicity, all shocks are assumed to travel at the same velocity, and the backloading time delay always includes any delay resulting from the breakup and clearing of the opening cover.

WALL ELEMENT RESPONSE

During previous research programs, SRI developed resistance functions for predicting the dynamic response and collapse of structural elements subjected to blast loading. For this study, the primary effort involved the development of the building subsystem program, with adaptation of the resistance functions and dynamic analysis technique available for wall elements for use as subroutines in the building subsystem program. A brief discussion of the dynamic analysis technique and the resistance function for unreinforced masonry walls used in the program follows.

Dynamic Analysis Technique

For the previous studies, single-degree-of-freedom system analogies have been used almost exclusively in predicting the dynamic response of beams, columns, beam-columns, slabs, and walls. Because of the many unknown factors involved in the dynamic analysis of actual buildings and because of the highly nonlinear behavior of structural elements at deflections approaching collapse, the single-degree-of-freedom system was adopted. The primary factor in the development of a realistic mathematical model with this method is first to develop a resistance function that adequately predicts the load-deflection history of the member, and then to transform the actual structural member into an equivalent single-degree-of-freedom system. Experience in correlating the predictions of the mathematical models with test data has shown that the single-degree-of-freedom model can predict the response to an accuracy compatible with the accuracy to which the load and element characteristics of buildings are known.

The simplified analysis reduces a continuous structural system to an energy-equivalent system based on a spring-mass-dash pot system. The procedures used for these transformations are well-established and have been used for many years.[13,14,15] The procedure consists of (1) assuming a deflected shape that relates the deflection

of all points of the element to a reference deflection and (2) equating the kinetic energy, strain energy, and work done for the actual structural element, deflected according to the assumed deflected shape, with corresponding energy expressions for the single-degree-of-freedom equivalent mass, spring, and dash pot system.

Resistance Function

Because the SRI wall resistance functions were primarily developed to determine the incipient collapse of a wall element, the computer program did not include provisions for a reversal of the net load on a wall. Rather, it only included provisions for a monotonically increasing deflection of the wall. That is, if a wall element reached its maximum deflection under a specific blast loading and did not collapse, the subsequent wall response was of no interest and the analysis was terminated; hysteretic effects were therefore not included in the wall resistance function.

The front exterior walls of a building loaded by a blast wave at normal incidence primarily respond inward, as do the side and rear walls of a windowless building. However, for the more usual case of a building with an opening in the front wall, the blast wave will reflect from the front wall and enter the opening creating a room-filling pressure that opposes and may exceed the exterior wall surface loading.

For a building with windows, the front wall is initially loaded inward, and as the room pressure increases the net wall load approaches zero; a load reversal does not occur because the exterior pressure is equal to or greater than the room pressure. For the sidewall of a building with windows in the front wall, the blast wave enters the building through the openings, and the room pressure builds up while the blast wave travels down the sidewall. The net load on a sidewall is usually initially inward, but as room pressure increases and exterior pressure decreases there may be a reversal of net load. If the blast wave is insufficient to collapse the wall during its inward response, the motion may reverse, and the wall may collapse outward under the irfluence of the room pressure. For such cases, the wall resistance function must include hysteretic effects.

The resistance function developed previously for a simply supported unreinforced masonry wall without arching is shown in Figure 2, and for a wall fixed on any of its edges[1,2] is shown in Figure 3. As noted in the figures, the resistance functions are characterized by an elastic phase(s) ending at a deflection y_u and a

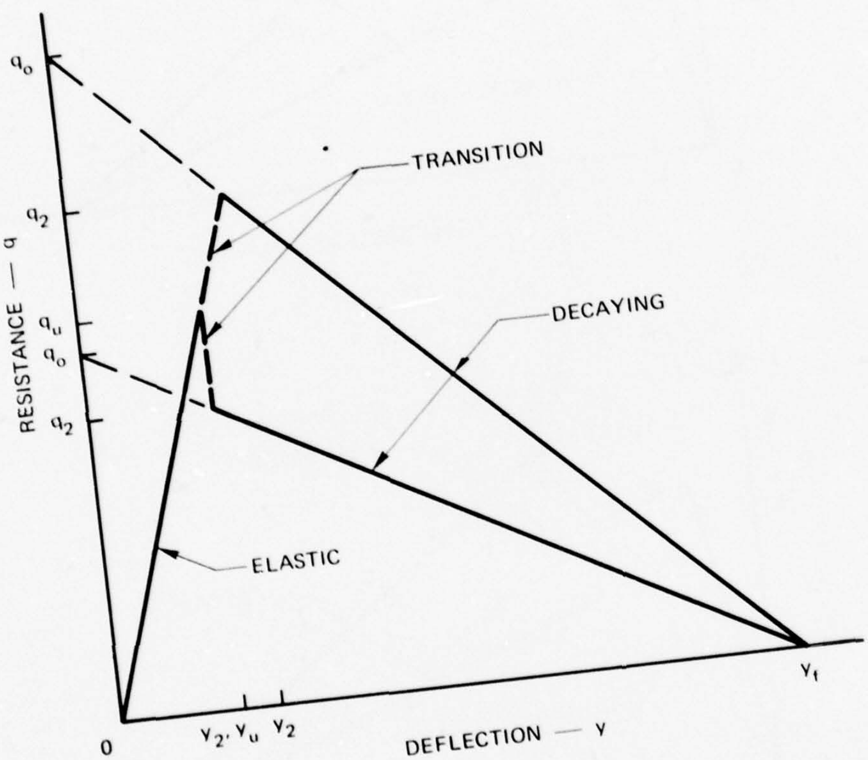

Figure 2. Resistance function for simply supported masonry walls without arching.

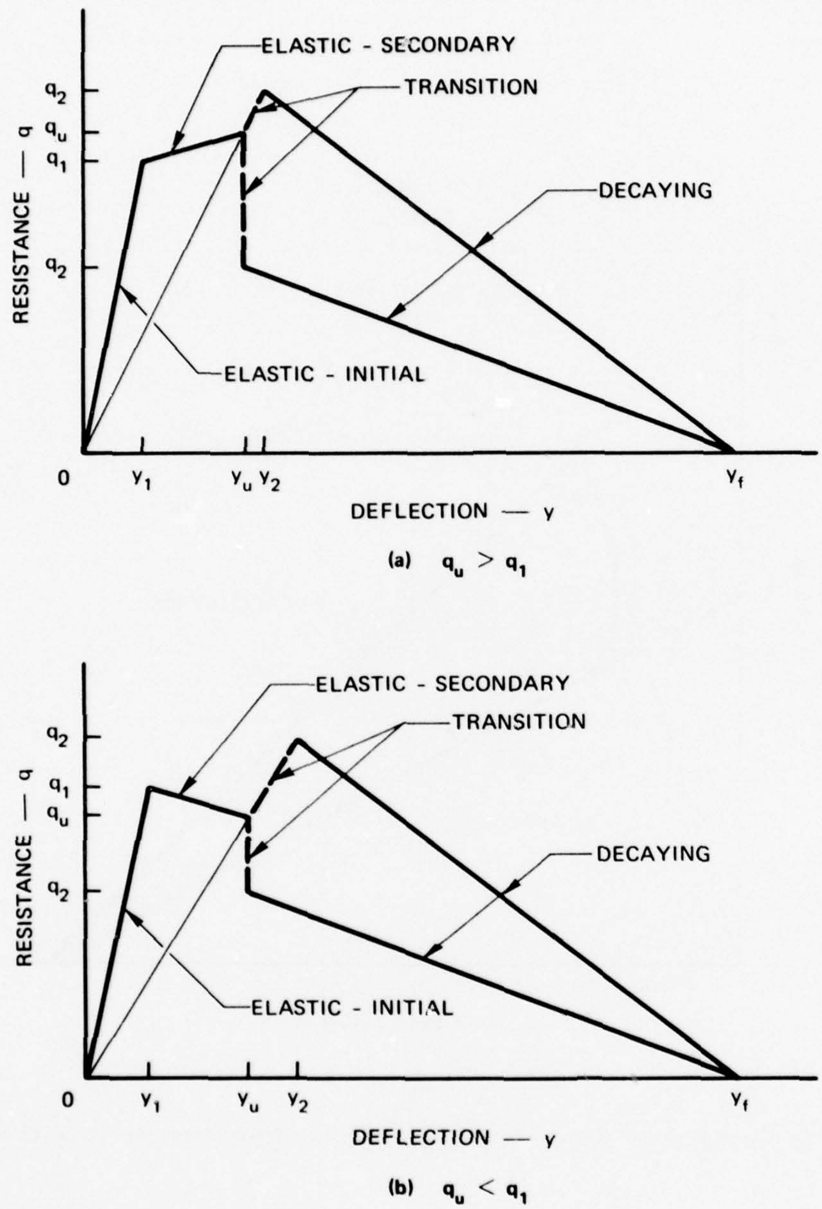

Figure 3. Resistance function for fixed edge masonry walls without arching.

decaying phase ending at *failure deflection* y_f. The elastic and decaying phases are joined by a transition phase which meets the decaying phase at deflection y_2. When the elastic phase is bilinear (as in Figure 3), the first elastic segment ends at deflection y_1. The elastic phase is controlled by the bending strength and the wall cracks when the modulus of rupture or tensile bond strength is reached. Subsequent to flexure failure, the wall resistance is provided by the geometry of the wall and the magnitude of the vertical axial forces in the plane of the wall (equilibrium resistance). For this study, the resistance functions shown in Figures 2 and 3 were modified to include hysteretic effects.

The basic resistance function for simply supported unreinforced masonry walls adopted for the building subsystem program is shown in Figure 4 for the case in which the magnitude of the elastic resistance is greater than that of the decaying resistance. If the blast loading is sufficient, the wall can respond and collapse during the first quarter cycle of deflection y in either direction as indicated by the arrows. However, if a load reversal occurs before collapse, the wall may initially respond in one direction, then reverse direction and collapse in the other direction. Because the wall indicated in Figure 4 may reverse direction while in either the elastic or decaying phases, two additional cases must be considered.

As shown in Figure 5, the wall may initially respond elastically in the positive direction but reverse direction before reaching the cracking deflection y_u. The wall would then respond in the negative direction as shown by the arrows and collapse at a deflection of $-y_f$ after passing through the elastic and decaying phases. For the other case, the wall may reach the positive decaying phase, between y_u and y_f shown in Figure 2, before reversing direction. Because the wall has exceeded its elastic strength and cracked, it cannot return through either the positive or negative elastic phases; after cracking the wall resistance consists of only the equilibrium resistance. For this program, it was assumed that on reversal of motion after cracking, say in the positive direction, the wall resistance follows the decaying resistance curve until it intersects the elastic curve, which it then follows to the intersection of the negative decaying resistance, and the wall may collapse at a deflection of $-y_f$ as shown in Figure 6.

Although it will not be discussed in detail, a similar approach was used to predict the hysteretic behavior of unreinforced masonry walls with one or more edges fixed, as shown in Figure 3.

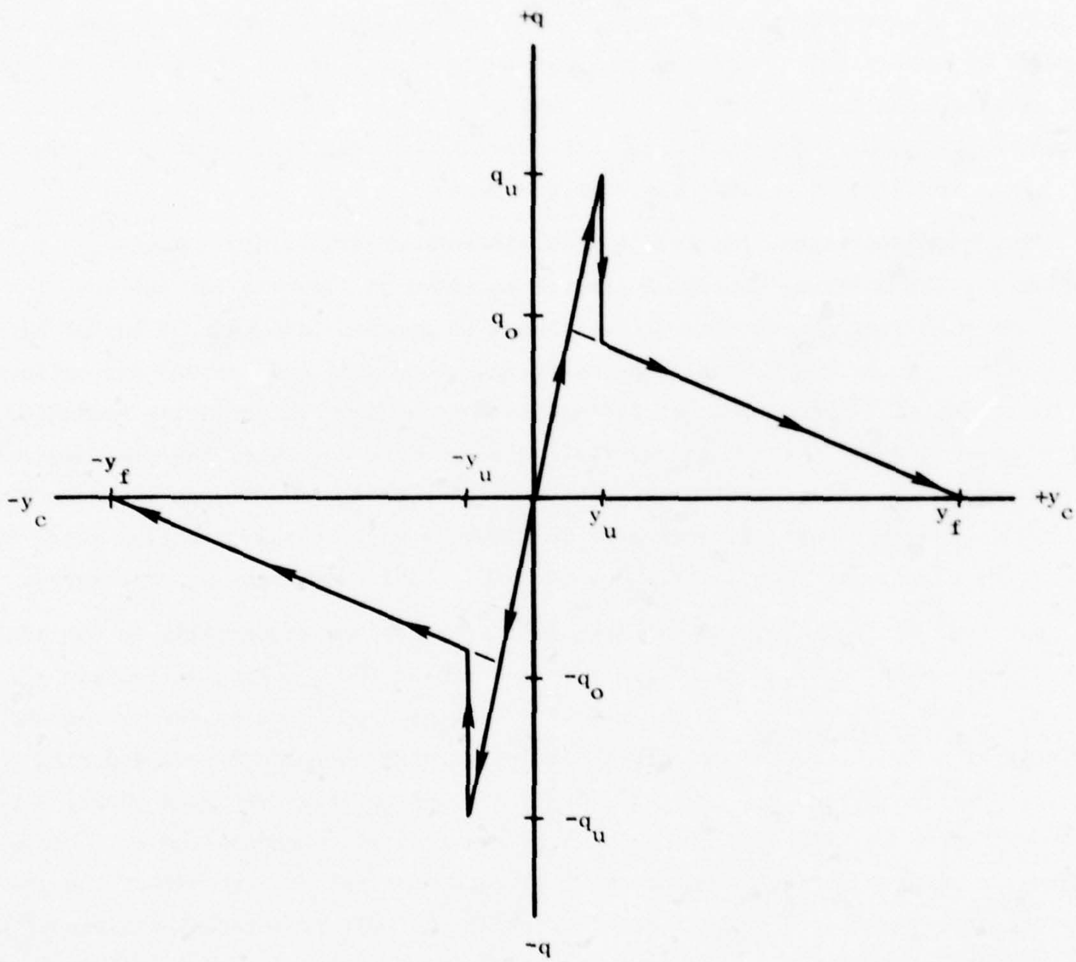

Figure 4. Resistance function for simply supported unreinforced masonry with hysteretic behavior.

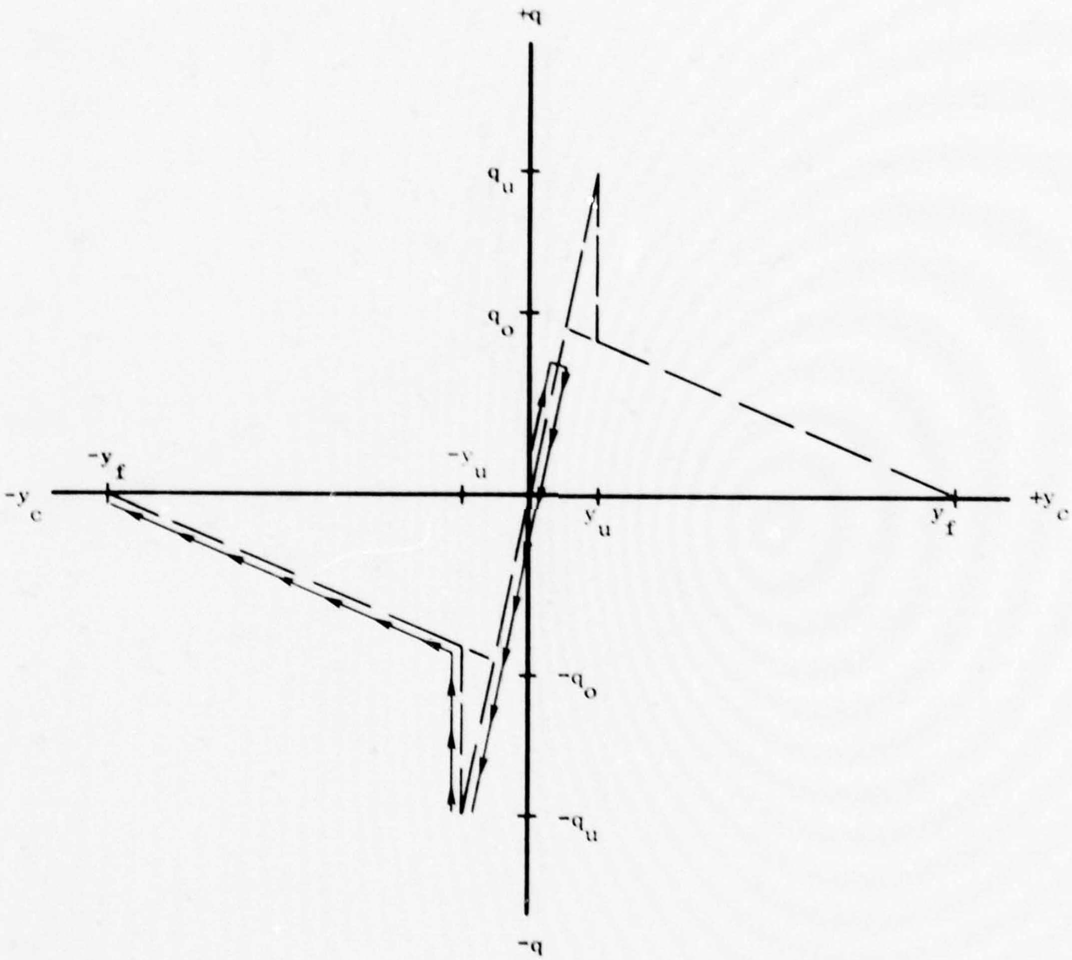

Figure 5. Hysteretic behavior of unreinforced masonry wall with reversal of deflection before cracking.

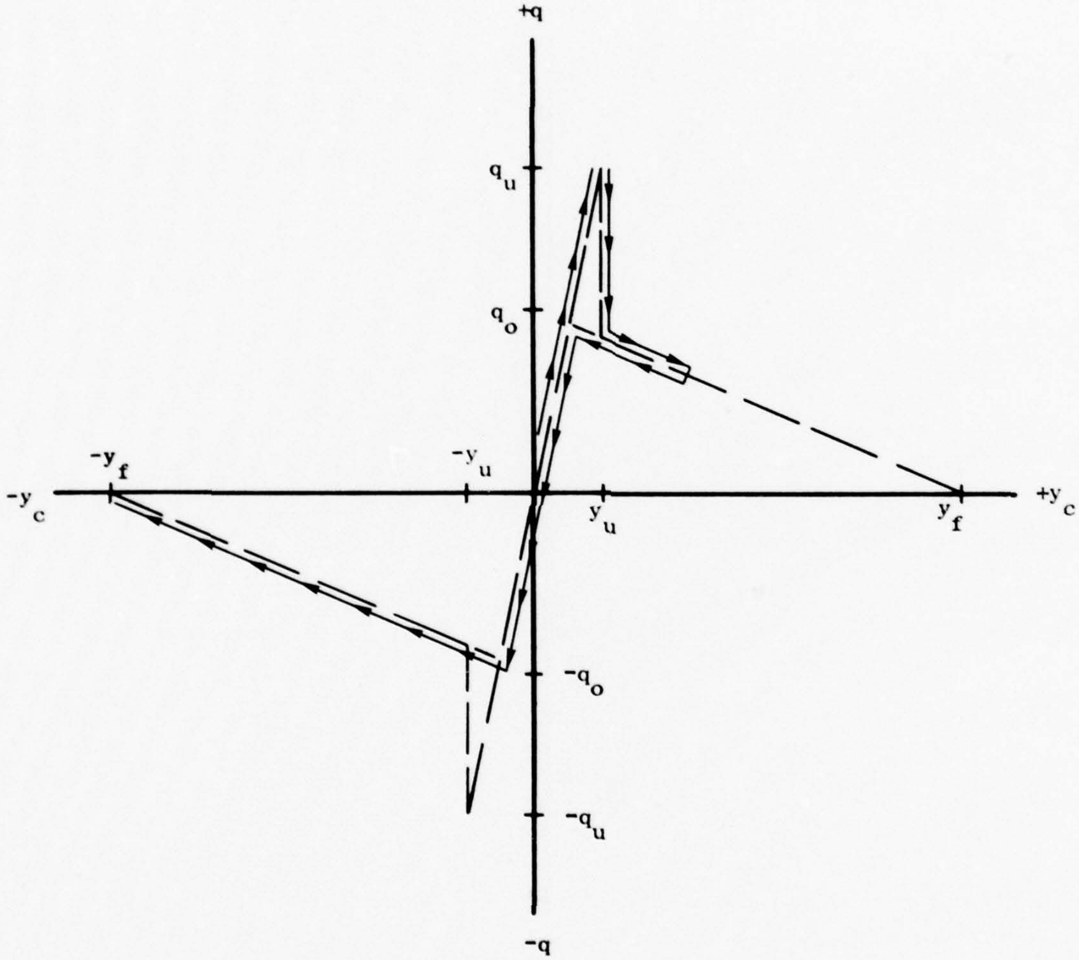

Figure 6. Hysteretic behavior of unreinforced masonry wall with reversal of deflection after cracking.

IV SUMMARY AND RECOMMENDATIONS

In its present form BRACOB can simultaneously analyze the dynamic response and collapse of all exterior unreinforced masonry walls on one story level of a building. The results reported here demonstrate that automated calculation of the collapse of all walls of a building engulfed by a blast wave is feasible. In fact, the relatively small storage requirements and the speed during the operation of the test cases make it evident that considerable sophistication can be added to the present program without burdening modern computers or significantly increasing the cost of running.

In its present form BRACOB can be used to simulate several blast-building interactions, most particularly the test of the German masonry house walls at Operation Dice Throw in 1976.[9] Although the Dice Throw structure was relatively simple and simulation of the Dice Throw blast-building interaction would not exercise most of the power of BRACOB, certainly the results of the field test should be evident in a computer simulation. Such a simulation is therefore recommended.

It is also recommended that, before BRACOB be applied to other field problems, some enhancements be made. The two foremost of these are addition of the ability to treat oblique blast front incidence and automation of the calculation of clearing time. These two features are related in their physical bases. Peak reflected pressure at oblique incidence is accessible to calculation, although the computation is complicated. Pressure erosion, however, has not been reduced to a satisfactory engineering computation, particularly when blast incidence is oblique. Reference 10 presents a simple method of calculating clearing time for normal incidence without considering openings in the wall. A more sophisticated procedure in Ref. 13 (again valid only for normal incidence) takes the enhancement of clearing by openings into account but has certain inconsistencies as has been shown in Ref. 2. Clearly, incorporation of oblique incidence and automatic calculation of clearing time will require some expansion of available techniques. A possible point of

departure in seeking the solution has been suggested by Taylor[16], who has reexamined clearing of a blast front reflected at normal incidence.

Before BRACOB can be applied generally the remaining SRI wall analysis programs must be incorporated as subroutines. This would enable analysis of buildings with arching walls and reinforced walls. Floor analysis might also prove useful eventually, particularly for floors over basements. However, such analyes would require considerable additional logic, as would the addition of treating more than one story simultaneously. Such treatment would be useful only in those cases when events on different stories were expected to interact, such as the removal of in-plane vertical load by collapse of an upper story wall or the joining of rooms on different stories as a result of floor collapse. It would seem that improvement in that direction might wait until other more pressing improvements had been undertaken, particularly the addition of floors over basements.

The SRI wall response analysis programs were designed to treat single wall panels under specified conditions of support at their edges. During the calculation, these support conditions are assumed to remain unchanged. When the edge support for a wall panel comes from another wall panel also subject to the same blast wave, as found in the mutual support between walls meeting at an outside corner, support conditions may not remain unchanged during the response of either wall. In this case, the cracking of one member of the pair could change the support condition behind one edge of the other member; the collapse of one member would remove support. It is recommended that, after the exterior blast loading methodology is extended as suggested above, provision be introduced into BRACOB to alter the support condition of an outside wall during a calculation in the case just described. When this has been done, it will be feasible to continue the response calculation of walls attached at only one terminus instead of discontinuing the calculation as is now done.

At present BRACOB cannot calculate the response of an interior wall to changes in air pressure in the rooms on either side nor can the program calculate flow through openings in interior walls. It is recommended that introduction of these features not be given first priority in the remainder of the project, but that the need for them first be explored by applying the program to buildings with many interior walls.

When the building subsystems analysis has been extended as indicated above, the program needs to be tested by using realistic plans of a multiroom building. For this purpose the single-family residence in Meppen, West Germany, which was used

as a model in the Dice Throw design,[9] would be suitable. Comparison between computational results and experiment could be sought in simulations of field tests of masonry buildings exposed to blast at Operation Greenhouse[17] and Operation Teapot.[18] In a series of simulations in which different overpressures and angles of incidence are assumed, it should become apparent how important floor and interior wall response are to the overall building response. Succeeding improvements in BRACCB would be made accordingly.

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Appendix A

COMPUTER PROGRAM INPUT AND OUTPUT

INPUT

To make clear what is required for program input a simple but illustrative example will be discussed in detail. The floor plan for the example appears in Figure A-1. Note that a dashed grid overlays the floor plan in such a way that the grid lines fall in the middle of walls and pilasters and at the edges of openings. For clarification in the following explanation the top of the floor plan in Figure A-1 is designated as north and the left hand edge as west. The blast front moves from south to north. The dark rectangle in the eastern wall of the room first encountered by the blast represents a pilaster of width 0.30 m. All exterior walls are 0.193 m thick; the one interior wall is 0.180 m thick. The opening in the front wall has an area of 0.939 m^2. Other linear dimensions are shown in meters.

Table A-1 shows a series of card images representing all input required in this example. The first card expresses the ambient pressure in kilopascals; the second, ambient temperature in degrees celsius; and the third, peak free-field overpressure. The fourth and fifth cards complete the description of the blast: the fourth contains the weapon yield in terajoules, and the fifth contains the angle in radians between the normal to the front building wall and the incoming blast front. At the present stage this entry must be $\pi/2 = 1.571$.

The next four cards, numbers 6 through 9, contain gas dynamic coefficients: the drag coefficient of front (CDF), side- (CDS), and rear-facing (CDR) walls, and the discharge coefficient (DCOEF) to be used during room-filling.

The following block of data, cards 10 through 16, defines the grid. Card number 10 shows the number of grid lines in the east-west direction first (NGX) and the number of grid lines in the north-south direction (NGY). Cards 11 through 14 then define the three grid intervals in the east-west direction (DIMX); the next three, numbers 14 through 16, specify the intervals along the north-south axis (DIMY).

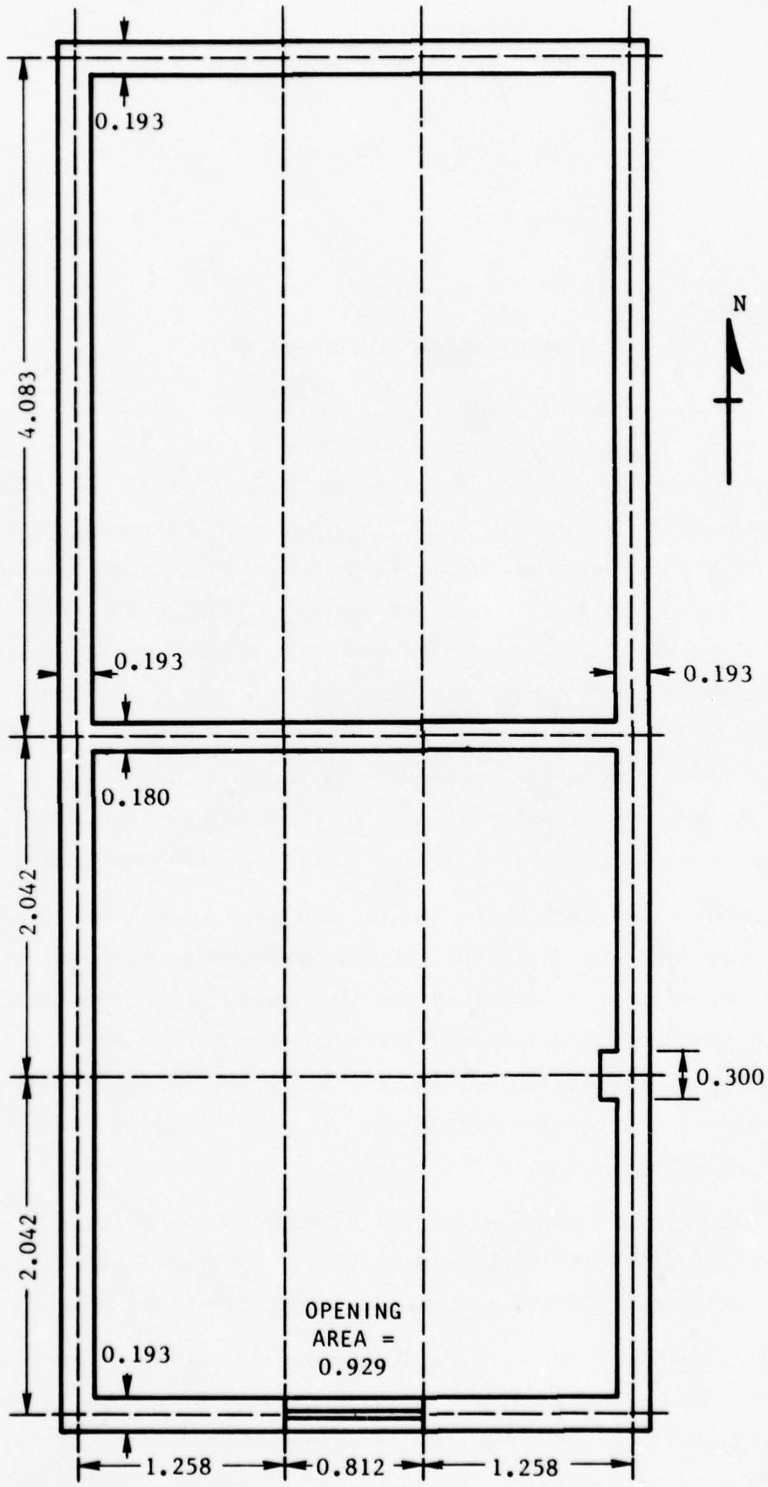

Figure A-1. Floor plan of illustrative example.

Table A-1. Input card images for illustrative example.

```
$DATA
   101.352
    15.
    48.263
     4.184
     1.571
     1.0
-    0.4
-    0.4
     0.7
    4    4
     1.258
     0.812
     1.258
     2.040
     2.040
     4.083
         1
         2         4      .3
     1.        1.
-     .929     0.
     1.        0.
     0.        1.
     0.        1.
     0.        0.
     0.        0.
     0.        1.
     1.        1.
     1.        0.
     1.        0.
     0.        1.
     1.        0.
     1.        0.
     1.        0.
     0.        0.
         0         0         0         0
     0.193
     0.18
     1.
     2.642
      .003
         2     689.5    8001.5   24130.0 0.689E+07    1361.6
      .014
      .014
   100.
         2     689.5    8001.5   24130.  0.689E+07    1361.6
$STOP
```

The entry in card 17 is the number of pilasters on the floor (NPLSTR); each pilaster requires one card following card 17 to carry the location in grid coordinates and width of each pilaster, as illustrated in this case by the single card number 18 (PLSTR).

Next follows the block of cards that defines the walls of the floor plan, in this case cards 19 through 30. There is one card for each grid intersection in the order (1,1), (2,1), (3,1),..... where the first number in each pair is the sequence number of the east-west grid line (abscissa), where the second is the north-south sequence number (ordinate), and where sequences are counted from south to north and from west to east. Each card in this block contains a pair of numbers; if the first of the pair is not zero, there is a wall emerging from the grid intersection in an easterly direction; a nonzero second number indicates a wall going north. If the outside walls are not of the same thickness, their different thicknesses must be entered in the appropriate grid intersection card; the same is true of the interior walls. Because all inside walls in this illustrative example are of the same thickness, as are all outside walls, the presence of walls at intersections has been shown everywhere by entry of 1 rather than a number representing thickness. The negative entry in card 20 gives the negative of the opening area located in the east-west wall at the corresponding grid intersection.

Card 31 contains four zeroes because all outside walls have the same thickness (KTHO = 0) and structural properties (KPRO = 0), and all inside walls have the same thickness (KTHI = 0) and structural properties (KPRI = 0). Were this not true, one or more of the entries would be a nonzero integer. Also because KTHO = 0 and KTHI = 0, both the outside and inside thicknesses must be stated on cards 32 and 33.

On card 34 the user may specify a maximum time (seconds) for simulation by the computation (TMAX). This entry will be effective only if it is shorter than the natural limits of the problem, such as passage of the blast wave or collapse of all walls. Card 35 contains the story height (HGHT) in meters, and card 36 indicates the opening breakage time (DELAY) in seconds.

Structural properties of outside walls are found on card 37 and properties of inside walls on card 41. Were all properties within each category of wall not the same, then cards similar to cards 37 and 41 would appear for each outside and inside wall. The sequence of required structural properties as illustrated on these cards is: support case (ICASE), modulus of rupture (FR) in kilopascals, in-plane vertical load (PV) in newtons per meter, compressive strength of masonry (FCP) in kilopascals,

modulus of elasticity (EM) in kilopascals, and wall material density (GAMMA) in kilograms per cubic meter.

The remaining three cards 38, 39, and 40 contain time information currently supplied by the user; on cards 38 and 39 are found the clearing times (TC) of the two exterior east-west walls, and card 40 contains the specified collapse time (CT) (measured from the moment of its first loading) of the one interior wall. All times are in seconds. In this case CT has been made large enough so that collapse will not occur.

The structural properties and their symbols used in the analysis carried out by this program are the same as those used in Refs. 1-7.

OUTPUT

The basis for interpretation of all output is the corner matrix (KIND). During computation, this matrix is kept current as walls collapse, and on program termination the final form of the matrix is printed. The initial corner matrix for the example problem discussed in this Appendix is pictured at the top of Figure A-2. In the matrix each grid intersection is represented by an integer term; each integer is a sequence of four digits made up of the two digits 0 and 1. (Leading zeroes are dropped unless the sequence contains no 1, in which case a single 0 is retained.) The grid intersection (1,1) corresponds to the matrix element (1,1) but intersection (2,1) corresponds to the element (1,2), where the first number of the pair identifies the row of the matrix element in accordance with the usual convention. If the grid intersection does not overlay a corner in the floor plan, the corresponding matrix element is zero. If, on the contrary, a corner is found at the grid intersection, the matrix element will contain two or more 1's, one 1 for each wall emerging from the corner). Furthermore, the direction of the wall represented by the digit 1 is shown by the position of the digit in the sequence (e.g., the corner at (1,1) is represented by 1010 because one wall goes north, none goes south, one wall goes east, and none goes west). The invariable order of walls in these representative integers is north, south, east, and west. The pilaster separates two north-south walls and counts as a two-way corner represented by the integer 1100.

The wall structure of the floor plan, implicitly contained in matrix KIND, is printed out as shown in the lower part of Figure A-2. East-west walls receive even sequence numbers; north-south walls, odd sequence numbers. Information on wall

```
SUBROUTINE CORNER
                    KINDS OF CORNERS

   1010     0     0 1001

      0     0     0 1100

   1110     0     0 1101

    110     0     0  101

                    E-W WALL NUMBERS

      2     2     2     0
      0     0     0     0
      4     4     4     0
      6     6     6     0

                    N-S WALL NUMBERS

      1     0     0     5
      1     0     0     7
      3     0     0     9
      0     0     0     0

   NO. OF E-W WALLS=    3
   NO. OF N-S WALLS=    5
              TOTAL=    8
```

Figure A-2. Corner matrix and wall numbers for illustrative example.

designations and locations is also listed in matrix form. In the example, there are clearly three east-west walls, numbered 2, 4, and 6 as well as four north-south walls, numbers 1 through 9.

Also available for output are any of the wall displacements and velocities identified by wall number.

Appendix B

FLOW CHART

Further understanding of program operation can be obtained from the flow chart in Figure B-1.

The program logic mainly falls into two divisions: organizational and temporal. The first includes such operations as locating walls and rooms, segregating inside and outside walls and openings, and computing arrival times and blast travel times. The temporal division includes operations related to the passage of problem time: calculation of wall motions and air flow, and determination of wall failure. Initially organization is followed by temporal, but any wall failure requires a certain amount of reorganization.

The first box in the flow chart refers to initialization of certain variables:

TFAIL(N)	Failure time of all walls = 1.E + 10
DEFL(N), VEL(N), ACCEL(N)	Deflection, velocity, and acceleration of wall N, set to zero
PLSTR(I,J)	Pilaster widths initially set to zero at all locations

Input is accomplished in two stages: The first is represented by the second box in the flow chart; the second stage must await organization and appears in the flow chart after the three organizing subroutines--CORNER, TRACE, and OUTER--have been called.

Variables evaluated by READ statements characterize the blast:

PO	ambient air pressure (kPa)
TEMP	ambient air temperature (^{o}C)
PSO	free field peak side-on overpressure (kPa)
TO	positive phase duration (s)

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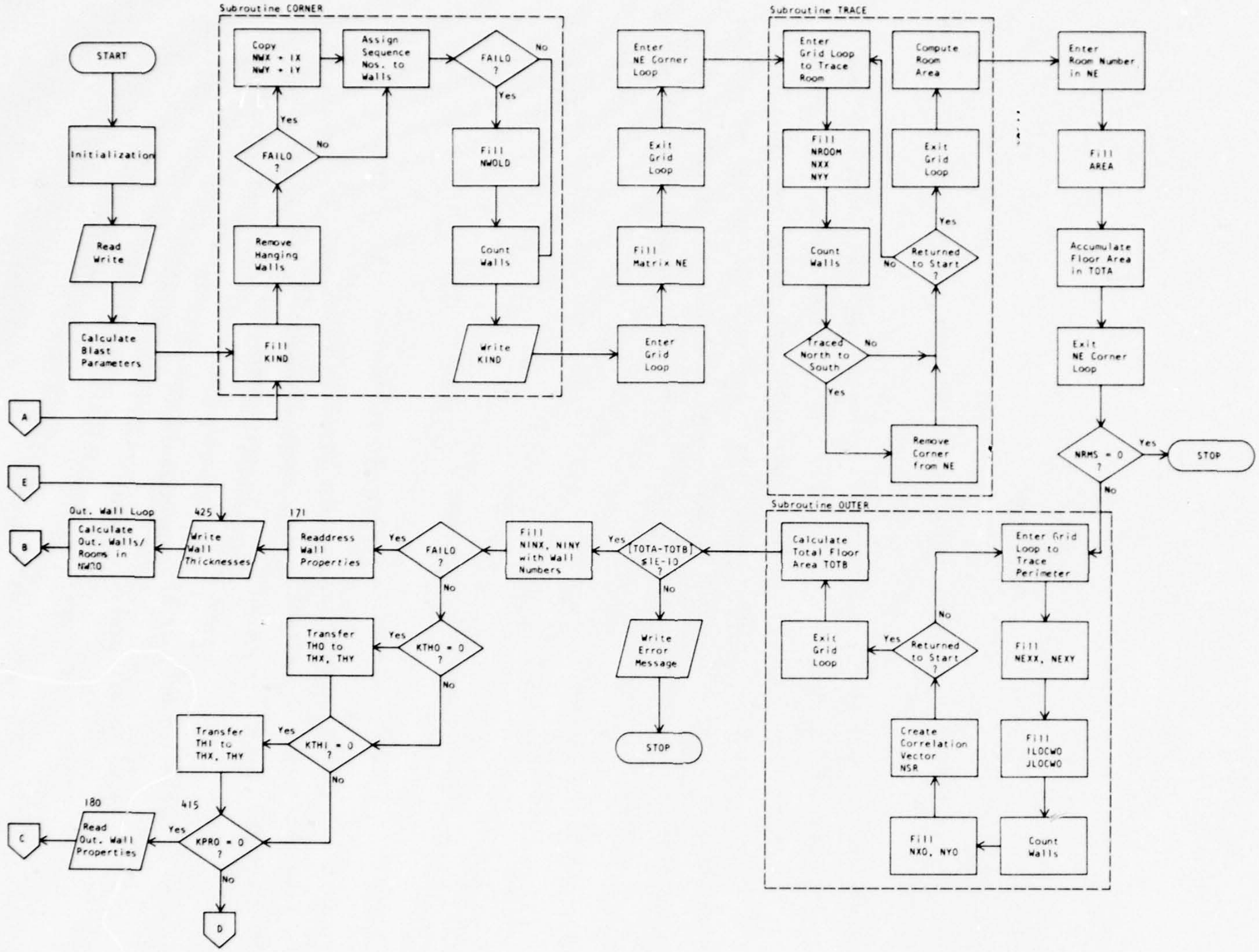

Figure B-1. Flow chart of program BRACOB

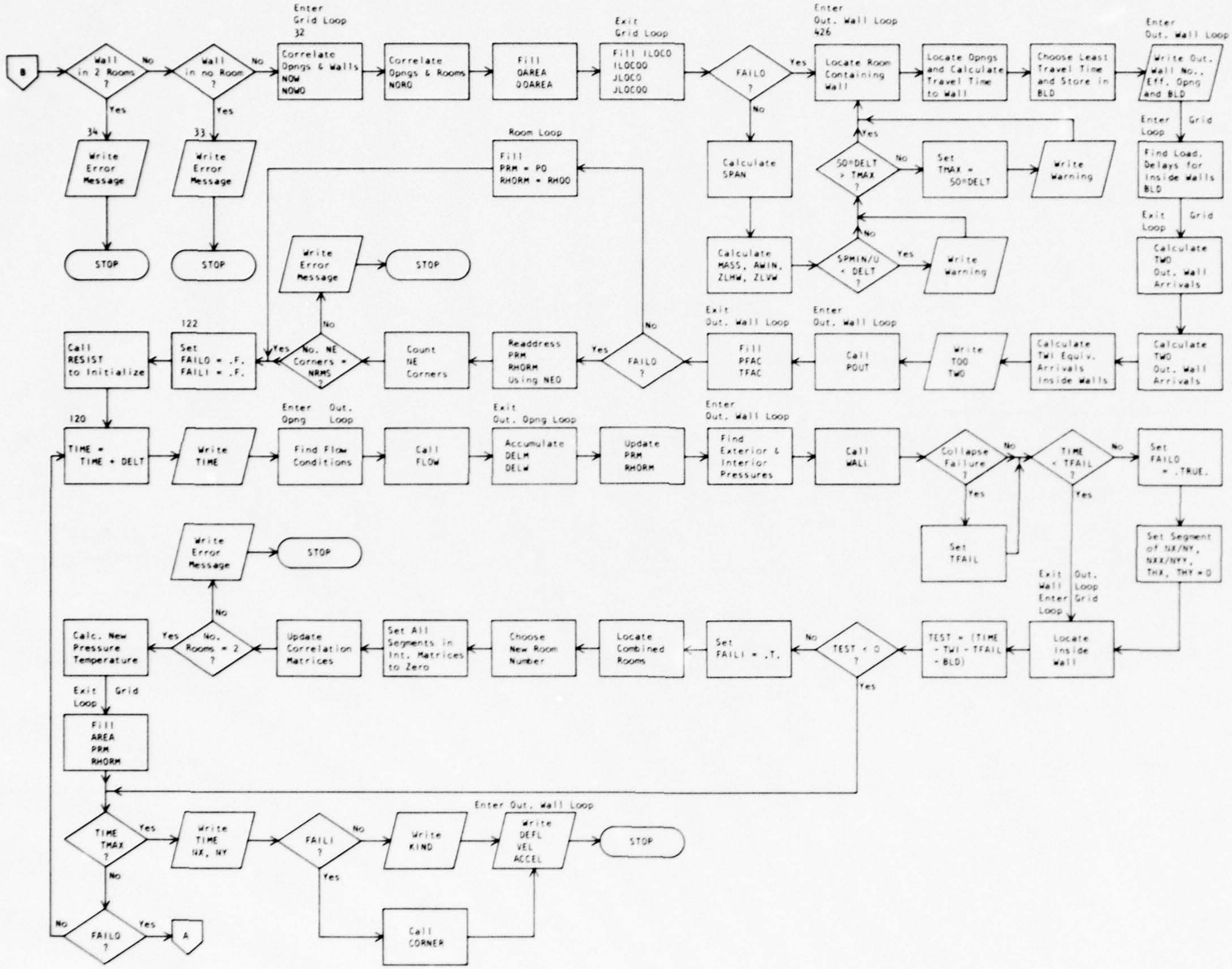

Figure B-1. (Continued.)

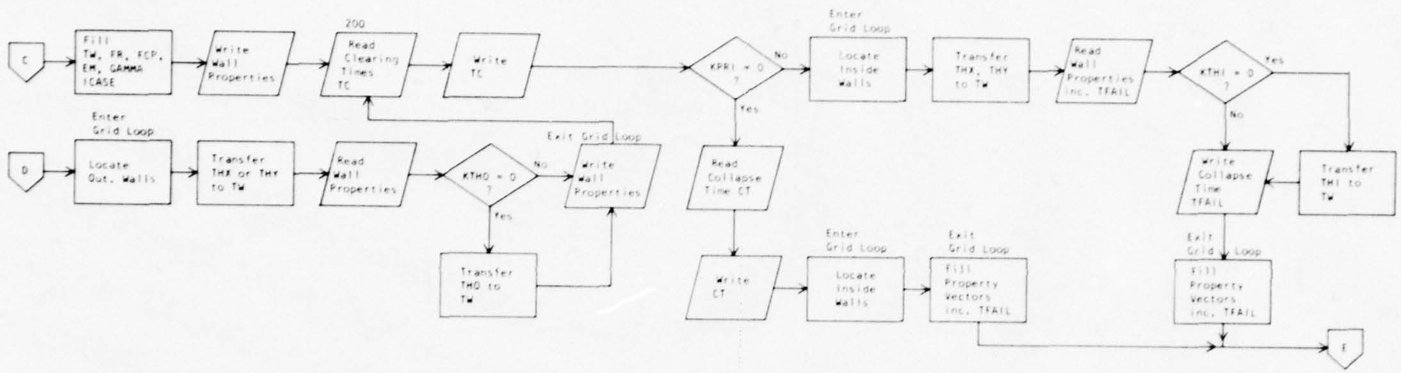

Figure B-1. (Concluded.)

ALPH	Angle of incidence between normal to front wall and blast front (radians)(now required to be $\pi/2$)
CDF	Drag coefficient of front-facing wall parallel to blast front
CDR	Drag coefficient of rear-facing wall
CDS	Drag coefficient of side-facing wall
DCOEF	Discharge coefficient applicable to all openings

Other variables describe the floor geometry:

NGX	Number of grid lines intersecting the x-axis
NGY	Number of grid lines intersecting the y-axis
DIMX(I)	(I has values from 1 to NGX-1) grid intervals along x-axis (m)
DIMY(I)	($1 \leq I \leq$ NGY-1) grid intervals along the y-axis (m)
NPLSTR	Number of pilasters on floor
I, J, PLSTR(I,J)	Grid location and width (m) of each pilaster (not required if NPLSTR = 0)
THX(I,J)	$1 \leq I \leq$ NGY $1 \leq J \leq$ NGX Thickness (m) of wall segment going eastward from grid location (I,J) or minus the area of opening in east-west wall beginning at (I,J)(m^2)
THY(I,J)	$1 \leq I \leq$ NGY $1 \leq J \leq$ NGX Thickness (m) of wall segment going north from (I,J) or minus the area of opening in north-south wall segment beginning at (I,J)(m^2)
KTHO, KTHI	Zero values for these codes indicate uniform thickness for all outside and all inside walls, respectively; when either code is zero the value entered for the corresponding thickness variable THO or THI replaces any nonzero positive value entered into THX and THY
THO, THI	Thickness of outside and inside walls, respectively (m); required only if corresponding thickness code KTHO or KTHI is zero
HGHT	Floor or wall height (m)

Six variables describe the properties of each wall N:

ICASE(N)	Support case (integer 1 through 7)
FR(N)	Modulus of rupture (kPa)

PV(N)	In-plane vertical load (N/m)
FCP(N)	Compressive strength (kPa)(not currently used)
EM(N)	Modulus of elasticity (kPa)
GAMMA(N)	Density (kg/m^3)

Finally, certain time information is required:

TMAX	Problem time limit (s)
DELAY	Opening breakage delay (s) for all openings on floor
TFAIL(N)	Time of failure of wall N (s), currently may be specified for inside walls; default value is 1.E + 10.

All input related to a specific wall N must await completion of the organizational phase.

Immediately on assignment of values for PSO, PO, TEMP, and TO, the program computes blast waves shapes, ambient air density, sound and shock speeds as suggested by the third box.

In its current form, the program echo prints all input information. All the calculated blast parameters are included as well.

The first important calculation in the program is the determination of the size of the time step. The choice must meet several standards. The time step DELT must be an order of magnitude smaller than the duration of any continuous change in the free field blast overpressure; it must be small enough to display progressive loading of walls and filling of rooms; and finally it can not be so small that computation and storage space are wasted. At present, DELT is set equal to TO/500 but not less than 0.001 s. A warning is printed (after organization) if DELT is greater than the shock transit time of the length of any wall.

Preparation for organization is begun by creation of the integer intersection matrices NX(I,J) and NY(I,J) from THX and THY. Any nonzero element in the thickness matrices causes an integer one to be entered at the same location in the corresponding intersection matrix; otherwise, NX and NY are filled with zeros. Organization itself is begun in subroutine CORNER, where the intersection matrices are manipulated to display the locations and natures of each corner on the floor in the integer matrix KIND(I,J). Each corner is characterized by a series of four digits; a corner at grid point (I,J) consisting of walls emerging north, south, east, and west,

for example, is shown by the integer number in the corresponding matrix element: KIND(I,J) = 1111. A three-way corner may be shown as KIND(I,J) = 1011, where a wall emerging south is absent. In these corner strings only the digits 0 and 1 are used and the directions always appear in the sequence: north, south, east, and west. Presence of a pilaster in a north-south wall, for example, is shown by: KIND(I,J) = 1100. Then subroutine CORNER recognizes walls from KIND and assigns even sequence numbers to east-west walls and odd numbers to north-south walls, storing these numbers in the intersection matrices NWX(I,J) and NWY(I,J). Each element in NWX and NWY is assigned the corresponding wall number. Subroutine CORNER also serves as the starting point for reorganization after an outside wall failure (FAILO = .TRUE.). As the flow chart shows in this case a correlation vector, NWOLD(new wall number) = old wall number, is created for later use by the main program in transferring information.

During the next phase, the main program examines KIND and lists all corners containing a north-east pair in matrix NE(I,J); that is, NE is zero-filled, except at those grid locations where both north- and east-going walls are found. For each such corner, subroutine TRACE is called to locate all the rooms on the floor, correlate rooms with the walls in them, and compute areas of each room. Because there may be more than one NE corner in a room, duplications of rooms are eliminated as soon as found, and the duplicate element in NE set to zero. Nor does every NE correspond to a room. Subroutine TRACE detects and rejects these as well. At the completion of the calls to TRACE, matrix NE contains one nonzero element for each room; the variable NRMS displays the correct number of rooms on the floor; and areas of rooms have been entered in the vector AREA(N) under a room sequence number N. A total floor area TOTA is obtained by summation for later checking. Just before a reorganization, matrix NE is duplicated in NEO to provide a means for readdressing room-keyed information.

The final stage in the organization process calls subroutine OUTER to segregate outer and inner walls. To save storage later in the exterior load matrices PFAC and TFAC, special outside wall numbers are assigned and stored in the intersection matrices NXO(I,J) and NYO(I,J); a correlation between the two series of wall numbers is kept in NSR(special wall number) = regular wall number. Subroutine OUTER also computes total floor area TOTB, which the main program compares with TOTA. Any significant descrepancy will lead to an error exit. For convenience, two intersection

matrices NINX(I,J) and NINY(I,J) in the main program show all interior wall segments by the wall number of which each is a part.

As the flow chart indicates, the logic branches after completion of the area check. During a reorganization, some information keyed to wall numbers must be re-addressed by using new numbers. Most importantly, wall material properties and inside wall failure times, as well as wall motions, are transferred by correlation vector NWOLD. Wall free spans SPAN, thicknesses TW, window areas AWIN, and window dimensions ZLHW and ZLVW are not recalculated on reorganization but are simply re-addressed.

However, on the first pass the program at this point reads in the wall properties of all walls and failure times (if desired) of inside walls. This information is echo printed for verification.

Both during reorganization and on the first pass, the next program phase consists of the assembly into convenient form of information required during the time iteration to calculate loads on outside walls. Outside openings are numbered and located by vectors ILOCOO and JLOCOO and associated with walls by correlation vectors NOW and with rooms in vectors NORO. Outside opening areas are stored in OOAREA. Blast arrival times t_a at outside openings are calculated from the vector relation

$$t_a = \vec{r}_{opng} \cdot \vec{U}/U^2$$

where $\vec{r}_{opng}$ is the vector from grid point (1,1) to the opening, and $\vec{U}$ is a vector representing the speed and direction of the shock front. Similarly, arrivals at all walls are calculated during this phase; for inside walls this is a nominal arrival time, computed as if the wall were an outside wall. Vectors TOO, TWO and TWI contain arrival times at openings, outside walls and inside walls, respectively. The basis for all calculations of vector distance is the pair of grid dimension vectors DIMX and DIMY.

For outside walls a back-loading delay is calculated as the least shock travel time to the wall from an outside opening in the same room; the delays stored in vector BLD. The breakage delay, named DELAY, is added to every value of BLD. For inside walls a similar value is calculated and stored in BLD to be used later along with TWI to start the clock that determines failure of the inside wall. For inside walls two rooms must be searched for outside openings.

As the next-to-last step before first entry into the time loop, the exterior load matrices PFAC and TFAC are filled by calls to subroutine POUT for each outside wall. POUT determines the orientation of the wall and computes 50 corresponding values of time and pressure in the time range from zero (or blast arrival at the wall) and either maximum problem time t_{max} or positive phase duration t_o, whichever is smaller. The first index in both PFAC and TFAC is the special outside wall number mentioned earlier. Because outside wall failure will change inside walls into outside walls, the calls to POUT are repeated during reorganization. The next to last step before reentry into the time loop is reallocation of storage to the room pressures and densities.

As the final step in all cases before entry into the time loop the initializing call to subroutine RESIST is made for all walls (although currently required only for the outside walls). This call causes the evaluation of load mass factors and the parameters defining the resistance function of each wall. After the first pass these initializing calls to RESIST could be replaced by simple transfer of data.

During each passage of the time loop, the variable TIME is increased by the addition of the time increment DELT, previously described.

The time loop itself contains four major logical loops passed through in the following order: outside openings, rooms, outside walls, and inside walls. During the first loop, air flow through each opening is calculated in subroutine FLOW, and the increments of mass and energy in each room are accumulated in vectors DELM and DELW. In the next step these accumulations are used to update room pressures and densities, so that in the next loop updated room pressures are available as back-pressures PINT against outside walls, if required. If the test, TIME ≧ TWO + BLD, fails, PINT is set equal to ambient pressure PO; otherwise, PINT is taken to be the average room pressure given by the room-filling calculation. Outside wall pressure PEXT is found by interpolation in the pair PFAC and TFAC using the wave time, TIME - TWO.

Outside wall motions are computed by calls to subroutine WALL, which in turn calls subroutine RESIST to find values of resistance Q necessary to its calculation of acceleration. WALL enters the current values of wall deflection, velocity, and acceleration into the vectors DEFL, VEL, and ACCEL, and reports any wall failure as well as the direction of failure. When an outside wall fails, the time, TIME + SQRT(AREA(NRM))/U, is entered into TFAIL for the wall. During the wall loop, TFAIL is checked to see if any outside wall should be removed at the current time and,

if so, the logical variable FAILO is set .TRUE. and a segment of the wall removed from NX or NY.

The final major loop within the time loop, namely the inside wall loop, is at first a simple inspection to see if any inside wall has failed: TIME ≧ TWI + BLD + TFAIL. (The "arrival time" TWI at an inside wall is the time the front would sweep over the inside wall poistion were the wall alone exposed.) If not, the final test on time, TIME ≧ TMAX is made. If it fails, control is returned to the start of the time loop or to subroutine CORNER, depending on the value of FAILO.

Should an inside wall have failed during the time step, a partial reorganization is undertaken within the inside wall loop. The adjoining rooms merged by the failure are identified and their pressures and densities combined. The higher room number is retired, and all its correlations are assigned to the lower number. All elements in intersection matrices corresponding to the failed wall are set to zero.

When problem time has expired (or all walls have been removed), the kinematics and locations of any remaining walls are reported and the program stops.

Appendix C

TEST CASES

To date, three test cases have been successfully run with BRACOB. In the first case, no wall response calculations were made, but four rooms were arranged in a moderately complicated plan (shown in Figure C-1); interior wall number 4 was specified to fail. In the second test case exterior wall number 6 was specified to fail. Both exterior and interior pressures were computed at all times, and reorganizations were performed correctly.

In Figures C-2 and C-3 the initial and final floor configurations in the first test case are represented by integer entries in matrix KIND. At matrix position (1,1) the corner is formed by two walls, one north-going, the other east-going. At position (2,1)* there is no corner, indicating that the east-going wall originating at (1,1) passes through point (2,1); the same is true at grid point (3,1), but at (4,1) the east-west front wall ends at a corner formed with a north-going wall. Further examination of KIND reveals two interior walls and a pilaster at (7,6). Also, there are five corners containing north-going and east-going walls in combination as shown by the five appearances of the format "1x1x," where "x" represents either zero or one. Each such NE corner tentatively defines a room. However, because there are only four rooms, the program chose to discard the possible room with the NE corner (4,10). The wall sequence numbers assigned by the program appear in the two matrices in Figure C-2 below KIND; the east-west walls have even numbers; the north-south walls, odd.

The final version of KIND and the final assignment of wall numbers appear in Figure C-3. Evidently the interior wall from (1,2) to (4,2) has been removed, as required by the specification in TFAIL, because the corner at (1,2) has disappeared and because the west-going wall no longer exists at (4,2).

---

* The coordinates here are specified in the order (x,y), where x is measured along the east-west axis. This contrasts to the matrix order, generally specified as (row, column).

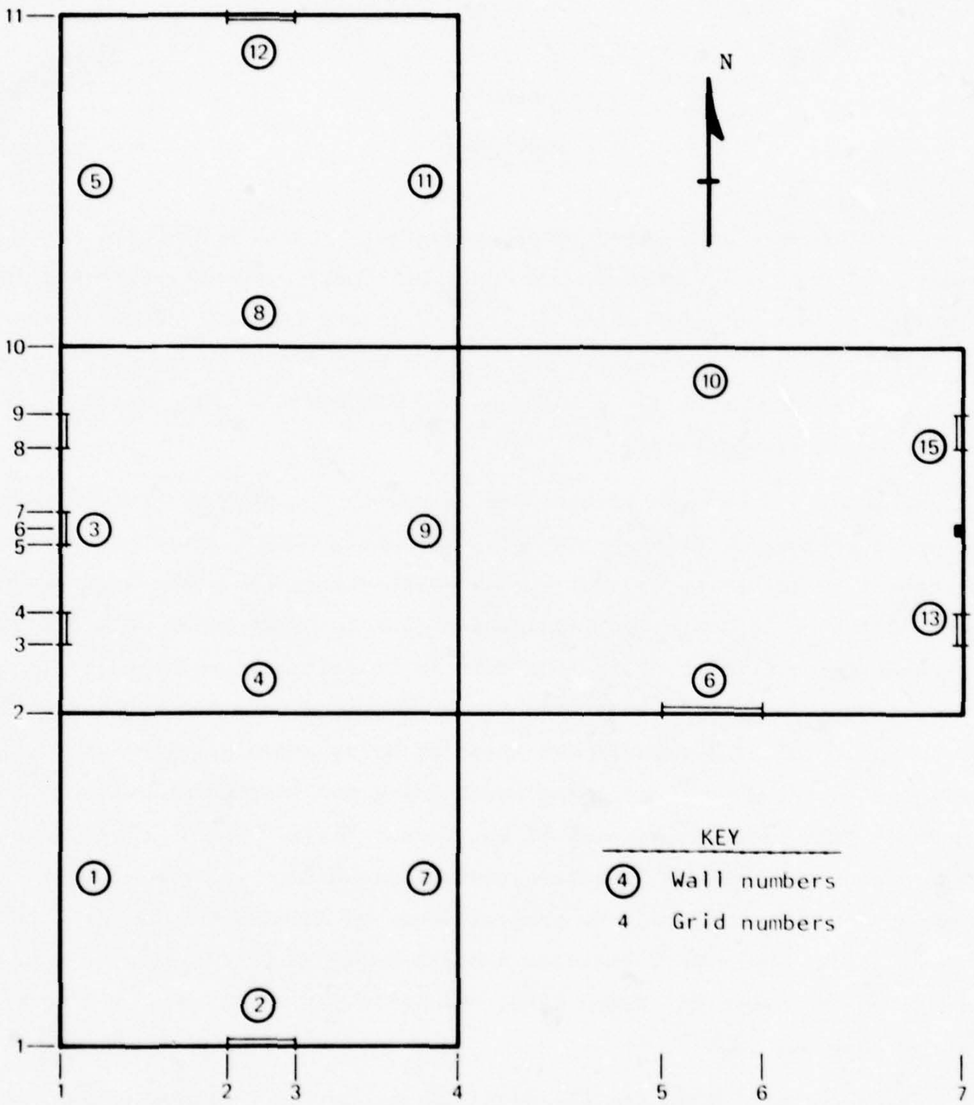

Figure C-1. Initial floor plan for first and second test cases.

SUBROUTINE CORNER

KINDS OF CORNERS

1010	0	0	1001	0	0	0
1110	0	0	1111	0	0	1001
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	1100
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1110	0	0	1111	0	0	101
110	0	0	101	0	0	0

E-W WALL NUMBERS

2	2	2	0	0	0	0
4	4	4	6	6	6	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
8	8	8	10	10	10	0
12	12	12	0	0	0	0

N-S WALL NUMBERS

1	0	0	7	0	0	0
3	0	0	9	0	0	13
3	0	0	9	0	0	13
3	0	0	9	0	0	13
3	0	0	9	0	0	13
3	0	0	9	0	0	15
3	0	0	9	0	0	15
3	0	0	9	0	0	15
3	0	0	9	0	0	15
5	0	0	11	0	0	0
0	0	0	0	0	0	0

NO. OF E-W WALLS= 6
NO. OF N-S WALLS= 8
TOTAL= 14

Figure C-2. Initial content of matrix KIND and wall numbers for first and second test cases.

SUBROUTINE CORNER

KINDS OF CORNERS

1010	0	0	1001	0	0	0
0	0	0	1110	0	0	1001
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	1100
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1110	0	0	1111	0	0	101
110	0	0	101	0	0	0

E-W WALL NUMBERS

2	2	2	0	0	0	0
0	0	0	4	4	4	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
6	6	6	8	8	8	0
10	10	10	0	0	0	0

N-S WALL NUMBERS

1	0	0	5	0	0	0
1	0	0	7	0	0	11
1	0	0	7	0	0	11
1	0	0	7	0	0	11
1	0	0	7	0	0	11
1	0	0	7	0	0	13
1	0	0	7	0	0	13
1	0	0	7	0	0	13
1	0	0	7	0	0	13
3	0	0	9	0	0	0
0	0	0	0	0	0	0

NO. OF E-W WALLS= 5
NO. OF N-S WALLS= 7

TOTAL= 12

Figure C-3. Final content of matrix KIND and wall numbers in first test case.

Comparable printout of the final state in the second test case, showing collapse of an outer wall, appears in Figure C-4. Note that although only one outside wall was required to collapse, the program has deleted all other outside walls in the room containing the collapsed wall.

Some of the output from the third test case, which uses the floor plan of Figure A-1, is reproduced in Figures C-5 through C-7. In Figure C-5 are found the original contents of matrix KIND showing the nature and locations of the corners in the unmodified floor plan. Examination of KIND reveals there are only two rooms in the floor plan, each corresponding to one NE corner, i.e., a corner containing walls going north and east. The sequence numbers assigned to the seven walls on the floor are listed in the two matrices appearing just below KIND.

Figure C-6 is a printout of some of the input for the third test case: a list of blast characteristics, grid intervals, and clearing times of outside east-west walls (i.e., those paralleling the blast front). Figure C-7 has some of the data on walls generated or relocated by the program.

Figure C-8 shows the matrix form of that plan after the blast has removed the front room. Running on an IBM 370/168 the program performed these calculations in 0.73 s, compiled in FORTRAN in 2.21 s, and required 512 K bytes of central memory.

SUBROUTINE CORNER

KINDS OF CORNERS

1010	0	0	1001	0	0	0
1110	0	0	1101	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1110	0	0	1101	0	0	0
110	0	0	101	0	0	0

E-W WALL NUMBERS

2	2	2	0	0	0	0
4	4	4	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
6	6	6	0	0	0	0
8	8	8	0	0	0	0

N-S WALL NUMBERS

1	0	0	7	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
3	0	0	9	0	0	0
5	0	0	11	0	0	0
0	0	0	0	0	0	0

NO. OF E-W WALLS= 4
NO. OF N-S WALLS= 6
TOTAL= 10

Figure C-4. Final contents of matrix KIND and wall numbers in second test case.

```
SUBROUTINE CORNER
                          KINDS OF CORNERS

      1010     0     0 1001

      1110     0     0 1101

       110     0     0  101

                          E-W WALL NUMBERS

         2     2     2     0
         4     4     4     0
         6     6     6     0

                          N-S WALL NUMBERS

         1     0     0     5
         3     0     0     7
         0     0     0     0

      NO. OF E-W WALLS=     3
      NO. OF N-S WALLS=     4
                 TOTAL=     7
```

Figure C-5. Initial matrix KIND and wall numbers for third test case.

```
PROGRAM FLOOR
    AMBIENT PRESSURE= 0.1014E 03 KPA
    AMBIENT TEMPERATURE= 0.2880E 03 KELVIN
    AMBIENT DENSITY= 0.1226E 01 KG/CUBIC METER
    PEAK SIDE-ON OVERPRESSURE= 0.4826E 02 KPA
    POSITIVE PHASE DURATION= 0.1100E 01 SEC
    ANGLE OF INCIDENCE TO X-AXIS=1.57
    DRAG COEFFS, FRONT,REAR AND SIDE=      1.0      -0.4      -0.4
    FLOOR HGHT= 0.2642E 01 METER
    OPNG BREAKAGE DELAY= 0.3000E-02 SEC

    SHOCK SPEED= 0.4037E 03 METER/SEC
    PEAK REFL OVERPRESSURE= 0.1150E 03 KPA
    PEAK DYN PRESSURE= 0.7685E 01 KPA


    GRID INTERVALS (METERS)

         EAST-WEST (X)

              1.258
              0.812
              1.258

         NORTH-SOUTH (Y)

              4.083
              4.083
```

Figure C-6. Echo print of input in third test case.

```
PROGRAM FLOOR
    OUTSIDE WALLS
      NO. E-W SEGMENTS=     6
      NO. N-S SEGMENTS=     4
      PROPERTIES    ICASE,FR,PV=    2     689.500 (KPA)    0.800E 04 (N/M)
                    FCP,EM,GAMMA=    0.241E 05 (KPA)    0.689E 07 (KPA)  1361.600 (KG/CUBIC M
```

CLEARING TIMES OF E-W WALLS

REG.SEQ. NO.	SPEC.SEQ. NO.	CLEARING TIME(SEC)
2	2	0.014
6	4	0.014

```
PROGRAM FLOOR
    FAILURE OF ALL INSIDE WALLS    0.100E 03 (SEC) AFTER LOADING
```

PROGRAM FLOOR

WALL NO.	THICKNESS (METER)
2	0.1930E 00
4	0.1800E 00
6	0.1930E 00
1	0.1930E 00
3	0.1930E 00
5	0.1930E 00
7	0.1930E 00

PROGRAM FLOOR

EXTERIOR WALL NOS. (REG. SERIES)

1 2 3 6 5 0 7 0

REG. WALL NO.	CLEAR SPAN (METER)
1	0.3896E 01
2	0.3135E 01
3	0.3896E 01
6	0.3135E 01
5	0.3746E 01
7	0.3746E 01

PROGRAM FLOOR

REG. WALL NO.	MASS (KG)	AREA (SQ.M)	OPNG AREA (SQ.M)	OPNG HGHT (METER)	OPNG WIDTH (METER)
2	0.1932E 04	0.7354E 01	0.9290E 00	0.1144E 01	0.8120E 00
4	0.1933E 04	0.7886E 01	0.0000E 00	0.0000E 00	0.0000E 00
6	0.2177E 04	0.8283E 01	0.0000E 00	0.0000E 00	0.0000E 00
1	0.2705E 04	0.1029E 02	0.0000E 00	0.0000E 00	0.0000E 00
3	0.2705E 04	0.1029E 02	0.0000E 00	0.0000E 00	0.0000E 00
5	0.2601E 04	0.9898E 01	0.0000E 00	0.0000E 00	0.0000E 00
7	0.2601E 04	0.9898E 01	0.0000E 00	0.0000E 00	0.0000E 00

Figure C-7. Wall data in third test case.

```
SUBROUTINE CORNER
                                KINDS OF CORNERS

          0        0        0        0

       1010        0        0     1001

        110        0        0      101

                                E-W WALL NUMBERS

          0        0        0        0
          2        2        2        0
          4        4        4        0

                                N-S WALL NUMBERS

          0        0        0        0
          1        0        0        3
          0        0        0        0

      NO. OF E-W WALLS=      2
      NO. OF N-S WALLS=      2
                TOTAL=      4
```

Figure C-8. Blast-modified matrix KIND in third test case.

Appendix D

PROGRAM LISTING

```
      COMMON /RMS/ NROOM(10,100), AREA(10),PRM(10),RHORM(10),NRMS
      COMMON /CRNR/ KIND(20,20),NE(20,20),PLSTR(20,20)
      COMMON /GRID/ NX(20,20),NY(20,20),NXX(10,20,20),NYY(10,20,20),
     1                DIMX(20),DIMY(20),NXO(20,20),NYO(20,20),NGX,NGY
      DIMENSION TWO(100),TOO(100),TWI(100)
      COMMON /BLAST/ PSO,TO,PO,ALPH,TEMP,DELT,RHOO,PR,CDF,CDR,CDS,QO,ALP
     1HA,BETA,A,B,TC(50),U
      COMMON /SPHT / G,G1,G2,G3,G4,G5,G6,G7,G0,CR,DCOEF
      COMMON /WAND/ NWX(20,20),NWY(20,20),NEXX(20,20),NEXY(20,20),NINX(2
     10,20),NINY(20,20),ILOCWO(100),JLOCWO(100),NSR(100),NWOLD(100),NW,N
     2W1,NW2,NWO,NWO1,NWO2,FAILO
      COMMON /PROP/ ICASE(20),FR(20),PV(20),FCP(20),EM(20),GAMMA(20
     1),SPAN(20),HGHT,TW(20)
      COMMON /TYM/ TIME
      COMMON /RESP/ DEFL(20),VEL(20),ACCEL(20),FIRST(20)
      COMMON /WNDW/ ZLHW(20),ZLVW(20),AWIN(20)
      COMMON /PROP1/ MASS(20),AWALL(20)
      COMMON /PROP4/ DUM(140),CRACK(20),Y4(20),REVERS(20)
      REAL MASS
      DIMENSION OAREA(50),OOAREA(50),PFAC(20,50),TFAC(20,50),NOWO(50)
     1,NSRO(50),DELM(10),DELW(10),BLD(50),V1(50),V2(50),V3(50),V4(50)
     2,V5(50),NEO(20,20),ILOCOO(50),JLOCOO(50)
      DIMENSION IHOLD(100),NWRO(50),JRM(50),          TFAIL(50),NOW(50),N
     1ORO(50),THX(20,20),THY(20,20),NXOO(20,20),NYOO(20,20),ILOCO(50),JL
     2OCO(50),LTMP(20)
      LOGICAL LF,LW,       FAILI,FAILO,L1,FAIL,OUT,OUTFLW,CRACK,REVERS
      LOGICAL LNE,FIRST,LTMP
      LNE(I)=(I.EQ.1010).OR.(I.EQ.1110).OR.(I.EQ.1011).OR.(I.EQ.1111)
C DENSITY OF DRY AIR AT P=76 CM HG, T=15 DEG C =1.226 KG/CUBIC METER $
C GAS CONST =8.3143 JOULE $ MOL. WT=28.97E-03 $
C    CDF=DRAG COEF, FRONT
C    CDS=DRAG COEF, SIDE
C    DCOEF=DISCHARGE COEF FOR ALL OPNGS
C IN FLOOR PLAN TOP OF PAGE IS NORTH, LEFT SIDE IS WEST $
C GRID POINT (1,1) IS IN LOWER LEFT HAND CORNER $
      RMW=8.3143/.02897
      DO  7 I=1,10
      DELM(I)=0.
    7 DELW(I)=0.
      DO 3 I=1,50
      TC(I)=0.
      TFAIL(I)=1.E+10
      NOWO(I)=0
    3 CONTINUE
      DO 17 I=1,20
      ZLHW(I)=0.
      ZLVW(I)=0.
      DEFL(I)=0.
      VEL(I)=0.
      ACCEL(I)=0.
      FIRST(I)=.TRUE.
      CRACK(I)=.FALSE.
      REVERS(I)=.FALSE.
   17 CONTINUE
      DO 8 I=1,20
      DO 8 J=1,20
      PLSTR(I,J)=0.
    8 CONTINUE
      LF=.FALSE.
      OUT=.FALSE.
C READ IN BLAST PARAMETERS:
C    PO=AMBIENT AIR PRESSURE (KPA)
C    TEMP=AMBIENT AIR TEMPERATURE (DEG C)
C    PSO=PEAK SIDE-ON OVERPRESSURE (KPA)
C    TO=POSITIVE PHASE DURATION (SEC)
C    ALPH=ANGLE BETWEEN WAVEFRONT & NORMAL TO BLDG FRONT (DEGREES)
C    YIELD=WEAPON YIELD IN TERAJOULES $ 1 KILOTON=4.184 TERAJOULES $
      READ(5,800)PO,TEMP,PSO,YIELD,ALPH,CDF,CDR,CDS,DCOEF
      TEMP=TEMP+273
      RHOO=1000.*PO/(TEMP*RMW)
      CSA=COS(ALPH)
  800 FORMAT(F10.3)
C NGX,NGY ARE NOS. OF GRID LINES IN X- AND Y-DIRECTIONS
      READ(5,801)NGX,NGY
      SNA=SIN(ALPH)
  801 FORMAT(2I5)
      NGX1=NGX-1
```

```
      NGY1=NGY-1
C DIMX,DIMY ARE DIMENSIONS OF X- AND Y-GRID INTERVALS (METERS)
      READ(5,800)(DIMX(I),I=1,NGX1)
      READ(5,800)(DIMY(I),I=1,NGY1)
      DIMX(NGX)=0.
      DIMY(NGY)=0.
C NPLSTR IS NUMBER OF PILASTERS ON THE FLOOR $
      READ(5,803)NPLSTR
  803 FORMAT(I10)
      IF(NPLSTR.EQ.0)GO TO 522
      DO 9 I=1,NPLSTR
      READ(5,802)II,JJ,TH
    9 PLSTR(II,JJ)=TH
  802 FORMAT(2I10,F10.3)
  522 CONTINUE
C PLSTR=0 MEANS NO PILASTER AT GRID POINT, OTHERWISE PLSTR GIVES WIDTH OF
C PILASTER AGAINST WALL IN METERS $
C THX,THY ARE WALL THICKNESSES (METERS) $
      DO 10 I=1,NGY
      DO 10 J=1,NGX
   10 READ(5,804)THX(I,J),THY(I,J)
C IF KTHO.EQ.0 THEN VALUE OF THO WILL OVERRIDE ANYTHING READ IN FOR THX,THY
C FOR AN OUTSIDE WALL EXCEPT ZERO $ SAME FOR INSIDE WALLS AND KTHI $
C NEGATIVE ENTRIES IN THX,THY REPRESENT AREAS OF OPNGS (SQ.M) $
  804 FORMAT(2F10.3)
C
C KTHO=0 MEANS ALL OUTSIDE WALLS HAVE SAME THICKNESS
C KTHI=0 MEANS ALL INSIDE WALLS HAVE SAME THICKNESS
C KPRO=0 MEANS ALL OUTSIDE WALLS HAVE SAME PROPERTIES
C KPRI=0 MEANS ALL INSIDE WALLS HAVE SAME PROPERTIES
C
      READ(5,806)KTHO,KPRO,KTHI,KPRI
  806 FORMAT(4I10)
      IF(KTHO.NE.0)GO TO 11
      READ(5,800)THO
   11 IF(KTHI.NE.0)GO TO 12
      READ(5,800)THI
C IF WALLS ARE OF SAME THICKNESS THEN PRESENCE OF WALLS REPRESENTED IN THX AND
C THY WITH ANY NON-ZERO VALUE $
   12 CONTINUE
      READ(5,800)TMAX
C TMAX IS FINAL PROBLEM TIME (SECONDS)
C G=RATIO SPECIFIC HEATS FOR AIR
C HGHT=ROOM HEIGHT=FLOOR HEIGHT (METERS)
C DELAY=BREAKAGE DELAY AT OPNGS (SECONDS)
      READ(5,800)HGHT
      READ(5,800)DELAY
C DERIVE INTERSECTION MATRICES NX,NY FROM THX,THY
      DO 1 I=1,NGY
      DO 1 J=1,NGX
      IF(THX(I,J).EQ.0)GO TO 2
      NX(I,J)=1
      GO TO 4
    2 NX(I,J)=0
    4 IF(THY(I,J).EQ.0)GO TO 6
      NY(I,J)=1
      GO TO 1
    6 NY(I,J)=0
    1 CONTINUE
C CURVE FIT IS DESIGNED FOR PSO EXPRESSED IN PSI $
      PS1=PSO/6.8947
      TMP=ALOG(PS1)
      ALPHA=.0270961+.335668*TMP
      BETA=1.92623+1.68236*TMP
      A=.932659-.00820025*PS1
      B=.0735423+.00834625*PS1
      PO7=7.*PO
      PO7P=PO7+PSO
      QO=2.5*PSO*PSO/PO7P
C SOUND SPEED CO IN METERS/SEC $
      CO=SQRT(1.4*8.3143*1.E+03*TEMP/28.961)
      U=CO*SQRT(1.+6.*PSO/PO7)
      PR=2.*PSO*(PO7+4.*PSO)/PO7P
C COMPUTE POSITIVE PHASE DURATION (SEC) FROM CURVE FIT TO EM-1 (1972)
C FOR 1 KT THEN SCALE TO YIELD $ VALID IN RANGE PSO=1 TO 50 PSI $
      TO=(1.8478/PSO)**.39429
      TO=TO*(YIELD/4.184)**.3333
```

```
C ALPHA,BETA,A & B ARE OVERPRESSURE WAVESHAPE PARAMETERS $
C QO=PEAK DYN. PRESS. $
C CO=SOUND SPEED AT TEMPERATURE=TEMP $
C U=SHOCK SPEED $
C PR=PEAK REFLECTED PRESSURE AT NORMAL INCIDENCE $
C ECHO PRINT INPUT TO THIS POINT
      WRITE(6,900)PO,TEMP,RHOO,PSO,TO,ALPH,CDF,CDR,CDS,HGHT,DELAY
  900 FORMAT(/14H PROGRAM FLOOR/5X,17HAMBIENT PRESSURE=,E11.4,4H KPA/5X,
     120HAMBIENT TEMPERATURE=,E11.4,7H KELVIN/5X,16HAMBIENT DENSITY=,
     2E11.4,15H KG/CUBIC METER/5X,26HPEAK SIDE-ON OVERPRESSURE=
     3,E11.4,4H KPA/5X,24HPOSITIVE PHASE DURATION=,E11.4,4H SEC/5X
     4,29HANGLE OF INCIDENCE TO X-AXIS=,F4.2,8H RADIANS/5X,33HDRAG COEFF
     5S, FRONT,REAR AND SIDE=
     6,3F8.1/5X,11HFLOOR HGHT=,E11.4,6H METER/5X,20HOPNG BREAKAGE DELAY=
     7,E11.4,4H SEC/)
      WRITE(6,910)U,PR,QO
  910 FORMAT(5X,12HSHOCK SPEED=,E11.4,10H METER/SEC/5X,23HPEAK REFL OVERPRESSURE=
     1PRESSURE=,E11.4,4H KPA/5X,18HPEAK DYN PRESSURE=,E11.4,4H KPA//)
      WRITE(6,901)
  901 FORMAT(/5X,23HGRID INTERVALS (METERS)//10X,13HEAST-WEST (X)/)
      DO 13 I=1,NGX1
   13 WRITE(6,902)DIMX(I)
  902 FORMAT(10X,F10.3)
      WRITE(6,903)
  903 FORMAT(/10X,15HNORTH-SOUTH (Y)/)
      DO 14 I=1,NGY1
   14 WRITE(6,902)DIMY(I)
      WRITE(6,904)
  904 FORMAT(//25X,21HINTERSECTION MATRICES//35X,2HNX//)
      DO 5 I=1,NGY
      WRITE(6,905)I
  905 FORMAT(/20X,2HI=,I5/)
    5 WRITE(6,906)(NX(I,J),J=1,NGX)
  906 FORMAT(27X,30I2)
      WRITE(6,907)
  907 FORMAT(//35X,2HNY//)
      DO 16 I=1,NGY
      WRITE(6,905)I
   16 WRITE(6,906)(NY(I,J),J=1,NGX)
      TIME=0.
      FAILO=.FALSE.
      WRITE(6,915)
  915 FORMAT(//28X,18HPILASTER LOCATIONS//)
      DO 15 I=1,NGY
      WRITE(6,908)I
   15 WRITE(6,923)(PLSTR(I,J),J=1,NGX)
      WRITE(6,914)TMAX
  914 FORMAT(//5X,17HMAX PROBLEM TIME=,E11.4,6H (SEC)/)
  908 FORMAT(10X,2HI=,I6/)
  923 FORMAT(10X,10F7.3)
      G=1.4
      G1=1./G
      G7=G-1.
      G2=G/G7
      G3=(G+1.)/G7
      G0=2./(G+1.)
      G4=G*G0**G3
      G5=2.*G2
      G6=1./G2
C CR=CRITICAL PRESSURE RATIO FOR DETERMINING CHOKED FLOW
      CR=G0**G2
      WRITE(6,916)KTHO,KTHI
  916 FORMAT(/5X,10HKTHO,KTHI=,2I3/)
      PI2=1.5707963
C DELT=TIME STEP. NOW SET EQ TO 1/500 TH POS. PHASE DURATION OR TMAX, WHICHEVER
C IS SMALLER $
      DELT=TO/500.
      T1=TMAX/500.
      IF(DELT.GT.T1)DELT=T1
      IF(DELT.LT..001)DELT=.001
      WRITE(6,918)DELT
  918 FORMAT(/5X,21HTIME STEP SIZE, DELT=,E12.4,1X,5H(SEC)/)
C CONVERT PRESSURES IN KPA TO PASCALS OR NEWTON/SQ.METER $
      PO=PO*1000.
      PR=PR*1000.
      PSO=PSO*1000.
C CALL SUBROUTINE CORNER TO FILL IN MATRIX KIND WITH CORNER DESCRIPTIONS
```

```
C RETURN HERE AFTER FAILURE OF OUTSIDE WALL $
C
  500 CALL CORNER
C
      NRMS=0
C FIND ALL NORTHEAST (NE) CORNERS $
      TOTA=0.
      DO 20 I=1,NGY
      DO 20 J=1,NGX
      K=KIND(I,J)
      IF(LNE(K))GO TO 19
      NE(I,J)=0
      GO TO 20
   19 NE(I,J)=1
   20 CONTINUE
C TRACE OUT WALLS IN EACH ROOM BEGINNING AT NE CORNER $ SUBROUTINE TRACE
C ELIMINATES ALL BUT ONE ENTRY IN MATRIX NE FOR EACH ROOM $
      DO 21 I=1,NGY
      DO 21 J=1,NGX
      IF(NE(I,J).EQ.0)GO TO 21
      NRMS=NRMS+1
      CALL TRACE(I,J,NRMS,AR)
C IF ROOM HAS BEEN TRACED OUT CLOCKWISE, IT IS A DUPLICATION AND
C MUST BE ELIMINATED $ SUBROUTINE TRACE HAS SET CORRESPONDING ENTRY
C IN MATRIX NE TO ZERO $
      IF(NE(I,J).EQ.0)GO TO 22
      AREA(NRMS)=AR
      NE(I,J)=NRMS
      TOTA=TOTA+AR
      GO TO 21
   22 NRMS=NRMS-1
   21 CONTINUE
      WRITE(6,912)NRMS
  912 FORMAT(/5X,10HNO. ROOMS=,I6/)
C IF ALL WALLS HAVE BEEN REMOVED, QUIT $
      IF(NRMS.EQ.0)RETURN
C SUBROUTINE OUTER LOCATES OUTER WALLS AND COMPUTES ANOTHER VALUE OF TOTAL
C FLOOR AREA, TOTB $ NA IS NO. OF GRID SQUARES $
      CALL OUTER(TOTB)
C COMPARE THE TWO VALUES FOR FLOOR AREA $
      TEST=ABS((TOTA-TOTB)/TOTA)
      IF(TEST.LE.1.E-04)GO TO 132
      WRITE(6,917)TOTA,TOTB
  917 FORMAT(/14H PROGRAM FLOOR/5X,10HERROR EXIT/5X,35HAREA TOTALS DONT
     1MATCH    TOTA,TOTB=,2E12.5/)
      CALL EXIT
  132 CONTINUE
C LIST REG. SEQ. NOS OF INSIDE WALLS IN MATRICES NINX,NINY $
      DO 160 I=1,NGY
      DO 160 J=1,NGX
      N=NWX(I,J)
      NINX(I,J)=0
      IF(N.EQ.0)GO TO 165
      IF(NEXX(I,J).NE.0)GO TO 165
      NINX(I,J)=N
  165 N=NWY(I,J)
      NINY(I,J)=0
      IF(N.EQ.0)GO TO 160
      IF(NEXY(I,J).NE.0)GO TO 160
      NINY(I,J)=N
  160 CONTINUE
C IF WALL THICKNESSES HAVE NOT BEEN READ IN, TRANSFER VALUES TO MATRICES
C THX & THY(I,J) $
C ON REORGANIZATION THIS IS NOT NECESSARY $
      IF(FAILO)GO TO 171
      IF(KTHO.NE.0)GO TO 161
      DO 166 I=1,NGY
      DO 166 J=1,NGX
      IF(THX(I,J).LT.0.)GO TO 167
      IF(NEXX(I,J).EQ.0)GO TO 167
      THX(I,J)=THO
  167 IF(THY(I,J).LT.0)GO TO 166
      IF(NEXY(I,J).EQ.0)GO TO 166
      THY(I,J)=THO
  166 CONTINUE
  161 IF(KTHI.NE.0)GO TO 415
      DO 168 I=1,NGY
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      DO 168 J=1,NGX
      IF(THX(I,J).LT.0)GO TO 169
      IF(NINX(I,J).EQ.0)GO TO 169
      THX(I,J)=THI
  169 IF(THY(I,J).LT.0)GO TO 168
      IF(NINY(I,J).EQ.0)GO TO 168
      THY(I,J)=THI
  168 CONTINUE
C IF THIS IS A REORGANIZATION TRANSFER WALL PROPERTIES TO NEW WALL NOS $
      GO TO 415
  171 CONTINUE
      DO 420 I=1,NW1
      II=2*I
C II=NEW WALL NO., N=OLD WALL NO.
      N=NWOLD(II)
      V1(I)=FR(N)
      V2(I)=PV(N)
      V3(I)=FCP(N)
      V4(I)=EM(N)
      V5(I)=GAMMA(N)
  420 IHOLD(I)=ICASE(N)
      DO 421 I=1,NW1
      II=2*I
      FR(II)=V1(I)
      PV(II)=V2(I)
      FCP(II)=V3(I)
      EM(II)=V4(I)
      GAMMA(II)=V5(I)
  421 ICASE(II)=IHOLD(I)
      DO 422 I=1,NW1
      II=2*I
      N=NWOLD(II)
      V1(I)=TC(N)
      V4(I)=TW(N)
      V5(I)=TFAIL(N)
  422 V3(I)=SPAN(N)
      DO 423 I=1,NW1
      II=2*I
      TW(II)=V4(I)
      TC(II)=V1(I)
      TFAIL(II)=V5(I)
      SPAN(II)=V3(I)
  423 CONTINUE
      DO 450 I=1,NW2
      II=2*I-1
      N=NWOLD(II)
      V1(I)=FR(N)
      V2(I)=PV(N)
      V3(I)=FCP(N)
      V4(I)=EM(N)
      V5(I)=GAMMA(N)
  450 IHOLD(I)=ICASE(N)
      DO 451 I=1,NW2
      II=2*I-1
      FR(II)=V1(I)
      PV(II)=V2(I)
      FCP(II)=V3(I)
      EM(II)=V4(I)
      GAMMA(II)=V5(I)
  451 ICASE(II)=IHOLD(I)
      DO 453 I=1,NW2
      II=2*I-1
      N=NWOLD(II)
      V1(I)=TC(N)
      V4(I)=TW(N)
      V5(I)=TFAIL(N)
  453 V3(I)=SPAN(N)
      DO 452 I=1,NW2
      II=2*I-1
      TW(II)=V4(I)
      TC(II)=V1(I)
      TFAIL(II)=V5(I)
      SPAN(II)=V3(I)
  452 CONTINUE
      DO 514 I=1,NW1
      J=2*I
      N=NWOLD(J)
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      V1(I)=DEFL(N)
      V2(I)=VEL(N)
      V3(I)=ACCEL(N)
      V4(I)=MASS(N)
      V5(I)=AWALL(N)
      LTMP(I)=FIRST(N)
  514 CONTINUE
      DO 515 I=1,NW1
      J=2*I
      DEFL(J)=V1(I)
      VEL(J)=V2(I)
      ACCEL(J)=V3(I)
      MASS(J)=V4(I)
      AWALL(J)=V5(I)
      FIRST(J)=LTMP(I)
  515 CONTINUE
      DO 516 I=1,NW2
      J=2*I-1
      N=NWOLD(J)
      V1(I)=DEFL(N)
      V2(I)=VEL(N)
      V3(I)=ACCEL(N)
      V4(I)=MASS(N)
      V5(I)=AWALL(N)
      LTMP(I)=FIRST(N)
  516 CONTINUE
      DO 521 I=1,NW2
      J=2*I-1
      DEFL(J)=V1(I)
      VEL(J)=V2(I)
      ACCEL(J)=V3(I)
      MASS(J)=V4(I)
      AWALL(J)=V5(I)
      FIRST(J)=LTMP(I)
  521 CONTINUE
      DO 519 I=1,NW1
      J=2*I
      N=NWOLD(J)
      V1(I)=AWIN(N)
      V2(I)=ZLVW(N)
      V3(I)=ZLHW(N)
  519 CONTINUE
      DO 518 I=1,NW1
      J=2*I
      AWIN(J)=V1(I)
      ZLVW(J)=V2(I)
      ZLHW(J)=V3(I)
  518 CONTINUE
      DO 517 I=1,NW2
      J=2*I-1
      N=NWOLD(J)
      V1(I)=AWIN(N)
      V2(I)=ZLVW(N)
      V3(I)=ZLHW(N)
  517 CONTINUE
      DO 520 I=1,NW2
      J=2*I-1
      AWIN(J)=V1(I)
      ZLVW(J)=V2(I)
      ZLHW(J)=V3(I)
  520 CONTINUE
      GO TO 425
C ENTER WALL PROPERTIES, OUTSIDE WALLS FIRST $
  415 IF(KPRO.EQ.0)GO TO 180
      WRITE(6,920)
  920 FORMAT(14H PROGRAM FLOOR/30X,17HOUTSIDE E-W WALLS/5X,8H  I     J,5X
     1,59HWALL NO.  ICASE     FR        PV        FCP         EM      GAMMA/36
     2X,5H(KPA), 2X,6H(KG/M),4X,5H(KPA),6X,5H(KPA),2X,7H(KG/M3)//)
      DO 170 I=1,NGY
      DO 170 J=1,NGX
      N=NEXX(I,J)
      IF(N.EQ.0)GO TO 170
      TW(N)=THX(I,J)
      READ(5,807)ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
      IF(KTHO.EQ.0)TW(N)=THO
      WRITE(6,921)I,J,N,ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
  807 FORMAT(I10,3F10.1,E10.3,F10.1)
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  921 FORMAT(5X,2I5,I10,F8.2,4E9.2,F8.2)
C CONVERT UNITS FROM KPA TO NEWTON/SQ.METER $
      FR(N)=FR(N)*1000.
      FCP(N)=FCP(N)*1000.
      EM(N)=EM(N)*1000.
  170 CONTINUE
      WRITE(6,913)
  913 FORMAT(30X,17HOUTSIDE N-S WALLS
     1        /5X,8H  I     J,5X,59HWALL NO.  ICASE     FR       PV        FC
     2P          EM       GAMMA//)
      DO 172 I=1,NGY
      DO 172 J=1,NGX
      N=NEXY(I,J)
      IF(N.EQ.0)GO TO 172
      TW(N)=THY(I,J)
      READ(5,807)ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
      IF(KTHO.EQ.0)TW(N)=THO
      WRITE(6,921)I,J,N,ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
  172 CONTINUE
      GO TO 200
  180 CONTINUE
      KX=0
      READ(5,807)M,A1,A2,A3,A4,A5
      KY=0
      DO 181 I=1,NGY
      DO 181 J=1,NGX
      N=NEXX(I,J)
      L1=.FALSE.
      IF(N.EQ.0)GO TO 182
      KX=KX+1
      TW(N)=THX(I,J)
      IF(KTHO.EQ.0)TW(N)=THO
  186 ICASE(N)=M
      IF(L1)KY=KY+1
      FR(N)=A1
      PV(N)=A2
      FCP(N)=A3
      EM(N)=A4
      GAMMA(N)=A5
C CONVERT UNITS FROM KPA TO NEWTON/SQ.METER $
      FR(N)=1000.*FR(N)
      FCP(N)=1000.*FCP(N)
      EM(N)=1000.*EM(N)
      IF(.NOT.L1)GO TO 182
      TW(N)=THY(I,J)
      IF(KTHO.EQ.0)TW(N)=THO
      GO TO 181
  182 N=NEXY(I,J)
      L1=.TRUE.
      IF(N.NE.0)GO TO 186
  181 CONTINUE
      WRITE(6,922)KX,KY,M,A1,A2,A3,A4,A5
  922 FORMAT(/14H PROGRAM FLOOR/5X,13HOUTSIDE WALLS/7X,
     117HNO. E-W SEGMENTS=,I5/7X,17HNO. N-S SEGMENTS=,I5/
     27X,25HPROPERTIES    ICASE,FR,PV=,I4,F12.3,6H (KPA),E12.3
     3,6H (N/M)/20X,13HFCP,EM,GAMMA=,E12.3,6H (KPA),E12.3,6H (KPA),F10.3
     4,17H (KG/CUBIC METER)/)
  200 CONTINUE
C READ IN CLEARING TIMES OF OUTSIDE E-W WALLS AND STORE UNDER REGULAR
C SEQ. NO. IN TC $ READ IN ORDER GOING CW FROM MOST SOUTHWESTERLY NE CORNER $
C CLEARING TIMES OF INSIDE E-W WALLS HAVE ALREADY BEEN SET TO ZERO
C SINCE ANY INSIDE WALL BECOMING AN OUTSIDE WALL WILL BE LOADED
C WITHOUT CLEARING DELAY $
      WRITE(6,935)
      DO 206 I=1,NWO2
      N1=2*I
      N=NSR(N1)
      READ(5,800)TC(N)
      WRITE(6,934)N,N1,TC(N)
  935 FORMAT(//26X,27HCLEARING TIMES OF E-W WALLS//24X,28HREG.SEQ.   SPEC
     1.SEQ. CLEARING/27X,3HNO.,8X,3HNO.,3X, 9HTIME(SEC)/)
  934 FORMAT(24X,I6,5X,I6,3X,F10.3)
  206 CONTINUE
C ENTER PROPERTIES OF INSIDE WALLS $
C ONLY INSIDE WALL PROPERTY NEEDED NOW IS COLLAPSE TIME CT $
C BUT ENTER INSIDE WALL THICKNESSES ALSO $
      IF(KPRI.EQ.0)GO TO 201
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      WRITE(6,925)
  925 FORMAT(/14H PROGRAM FLOOR/5X,26HINSIDE WALL COLLAPSE TIMES//5X,28H
     1WALL NO.   I    J    TIME(SEC)//)
      N1=0
      DO 205 I=1,NGY
      DO 205 J=1,NGX
      N=NINX(I,J)
      IF((N.EQ.0).OR.(N.EQ.N1))GO TO 203
      N1=N
      TW(N)=THX(I,J)
      READ(5,800)CT
      READ(5,807)ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
C CONVERT UNITS FROM KPA TO NEWTON/SQ.METER $
      FR(N)=FR(N)*1000.
      FCP(N)=FCP(N)*1000.
      EM(N)=EM(N)*1000.
      IF(KTHI.EQ.0)TW(N)=THI
      WRITE(6,926)N,I,J,CT
  926 FORMAT(I12,2I4,E12.3)
      TFAIL(N)=CT
  203 N=NINY(I,J)
      IF((N.EQ.0).OR.(N.EQ.N1))GO TO 205
      N1=N
      TW(N)=THY(I,J)
      READ(5,800)CT
      READ(5,807)ICASE(N),FR(N),PV(N),FCP(N),EM(N),GAMMA(N)
C CONVERT FROM KPA TO NEWTON/SQ.METER $
      FR(N)=FR(N)*1000.
      FCP(N)=FCP(N)*1000.
      EM(N)=EM(N)*1000.
      IF(KTHI.EQ.0)TW(N)=THI
      WRITE(6,926)N,I,J,CT
      TFAIL(N)=CT
  205 CONTINUE
      GO TO 425
  201 READ(5,800)CT
      WRITE(6,927)CT
      READ(5,807)M,A1,A2,A3,A4,A5
  927 FORMAT(/14H PROGRAM FLOOR/5X,29HFAILURE OF ALL INSIDE WALLS   ,E11.
     13,1X,19H(SEC) AFTER LOADING/)
C CONVERT FROM KPA TO NEWTON/SQ.METER $
      A1=A1*1000.
      A3=A3*1000.
      A4=A4*1000.
C ENTER COLLAPSE TIMES OF INSIDE WALLS IN VECTOR TFAIL MEASURED IN
C SECONDS AFTER LOADING OF WALL $
      DO 207 I=1,NGY
      DO 207 J=1,NGX
      N=NINX(I,J)
      IF(N.EQ.0)GO TO 208
      TFAIL(N)=CT
      ICASE(N)=M
      FR(N)=A1
      PV(N)=A2
      FCP(N)=A3
      EM(N)=A4
      GAMMA(N)=A5
      TW(N)=THX(I,J)
      IF(KTHI.EQ.0)TW(N)=THI
  208 N=NINY(I,J)
      IF(N.EQ.0)GO TO 207
      TW(N)=THY(I,J)
      IF(KTHI.EQ.0)TW(N)=THI
      TFAIL(N)=CT
      ICASE(N)=M
      FR(N)=A1
      PV(N)=A2
      FCP(N)=A3
      EM(N)=A4
      GAMMA(N)=A5
  207 CONTINUE
  425 K=0
C PRINT WALL THICKNESSES FOR ALL WALLS $
      WRITE(6,975)
  975 FORMAT(//14H PROGRAM FLOOR/25X,20HWALL NO.   THICKNESS/37X,7H(METE
     1R)/)
C NW1=NO. E-W (EVEN NUMBERED) WALLS $ NW2=NO. N-S WALLS $
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      DO 202 I=1,NW1
      II=2*I
  202 WRITE(6,976)II,TW(II)
      DO 209 I=1,NW2
      II=2*I-1
  209 WRITE(6,976)II,TW(II)
  976 FORMAT(25X,I6,2X,E12.4)
C IDENTIFY OUTSIDE WALLS AND CORRELATE WITH ROOMS BEHIND $
C NWRO(WALL NO.)=ROOM NO. WHERE WALL NO. IS REGULAR SEQ. NO. FOR OUTSIDE WALLS $
C NSR(SPEC.SEQ.NO.)=REG.SEQ.NO. FOR OUTSIDE WALLS $
C M=OUTSIDE WALL NO. IN REGULAR SEQ. $ I=SPECIAL OUTSIDE WALL NO. $
C IUP=LOOP SIZE TO INCLUDE ALL OF SPECIAL OUTSIDE WALL NOS $
      IUP=MAX0(NWO1,NWO2)
      IUP=2*IUP
      DO 30 I=1,IUP
      M=NSR(I)
      IF(M.EQ.0)GO TO 30
      L1=.FALSE.
      DO 25 J=1,NRMS
      IF(NROOM(J,M).EQ.0)GO TO 25
      IF(L1)GO TO 34
      L1=.TRUE.
      JJ=J
   25 CONTINUE
      IF(.NOT.L1)GO TO 33
      JRM(I)=JJ
C JRM(SPEC.SEQ.NO.OUT.WALL)=ROOM NO.
      NWRO(M)=JJ
   30 CONTINUE
      GO TO 32
   34 WRITE(6,977)M,I,JJ,J
  977 FORMAT(/14H PROGRAM FLOOR/5X,10HERROR EXIT/5X,25HOUTSIDE WALL IN T
     1WO ROOMS/5X,16HWALL NO. (REG.)=,I6,2X,10H(SPECIAL)=,I6,9HROOM NOS=
     2,2I6/)
      CALL EXIT
   33 WRITE(6,933)I,M,K
  933 FORMAT(/14H PROGRAM FLOOR/5X,10HERROR EXIT/5X, 24HOUTSIDE WALL HAS
     1 NO ROOM/5X,23HSPEC. OUTSIDE WALL NO.=,I5/5X,
     217HREG.SEQ.WALL NO.=,I5/5X,25HNO OUTSIDE WALLS COUNTED=,I5/)
      CALL EXIT
   32 CONTINUE
      WRITE(6,931)
  931 FORMAT(/14H PROGRAM FLOOR//25X,32HEXTERIOR WALL NOS. (REG. SERIES)
     1/)
      WRITE(6,932)(NSR(I),I=1,IUP)
  932 FORMAT(5X,14I5)
C NWO=NO. OF OUTSIDE WALLS $ NO=NO.OF OPNGS $ NOO=NO.OF OUTSIDE OPNGS $
      NOO=0
      NO=0
C ESTABLISH CORRELATION VECTORS FOR OPENINGS $
C NOW(OPNG NO.)=WALL NO. IN REGULAR SERIES $
C NOWO(OUTSIDE OPNG NO.)=WALL NO. IN REGULAR SERIES $
C NORO(OUTSIDE OPNG NO.)=ROOM NO.
      DO 40 I=1,NGY
      DO 40 J=1,NGX
      IF(THX(I,J).GE.0)GO TO 41
      NO=NO+1
C N=WALL NO. IN REGULAR SERIES $ NO=OPNG NO. IN REG. SERIES $
      N=NWX(I,J)
      NXOO(I,J)=NO
      NOW(NO)=N
      ILOCO(NO)=I
      JLOCO(NO)=J
C STORE OPNG AREA UNDER ITS SEQUENCE NO. $
      OAREA(NO)=-THX(I,J)
C NXOO,NYOO ARE INTERSECTION MATRICES CONTAINING SEQ.NOS. OF OPNGS $
C IF OPNG IS IN OUTER WALL ENTER SEQ. NO. IN SPECIAL CORRELATION MATRIX
C FOR OUTER ROOMS AND OPNGS,NORO $ COUNT NO. OF OUTSIDE OPNGS IN NOO $
C NOO IS A SEQ. NO. ONLY IN LOCATOR VECTOR LOCOO FOR OUTSIDE OPNGS
C AND IN ARRIVAL TIME VECTOR, TOO, AND IN CORRELATION VECTORS,NORO AND NOWO,
C AND IN OOAREA $
C N1=ROOM NO. BEHIND OUTSIDE WALL $
C A SINGLE OPNG DIVIDED BY A GRID LINE MUST BE ENTERED AS TWO OPNGS
      IF(NXO(I,J).EQ.0)GO TO 41
      N1=NWRO(N)
C N1=ROOM NO. $ NOO=OPNG NO. IN SPECIAL SERIES $ NSRO(SPEC.OPNG NO.)=REG.OPNG NO
      NOO=NOO+1
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      NSRO(NOO)=NO
      NORO(NOO)=N1
      NOWO(NOO)=N
      ILOCOO(NOO)=I
      JLOCOO(NOO)=J
      OOAREA(NOO)=-THX(I,J)
   41 IF(THY(I,J).GE.0)GO TO 40
      NO=NO+1
      NYOO(I,J)=NO
      N=NWY(I,J)
      ILOCO(NO)=I
      JLOCO(NO)=J
      OAREA(NO)=-THY(I,J)
      NOW(NO)=N
      IF(NYO(I,J).EQ.0)GO TO 40
      N1=NWRO(N)
C N=WALL NO.(REG.SEQ.), N1=ROOM NO. $
      NOO=NOO+1
      NSRO(NOO)=NO
      NORO(NOO)=N1
      NOWO(NOO)=N
      ILOCOO(NOO)=I
      JLOCOO(NOO)=J
      OOAREA(NOO)=-THY(I,J)
   40 CONTINUE
C BEGIN CALC OF CLEAR SPANS OF WALLS $ E-W WALLS FIRST $ SKIP IF REORG $
      IF(FAILO)GO TO 426
      SPMIN=1.E+70
      DO 60 I=1,NGY
      N1=0
      DO 60 J=1,NGX
      N=NWX(I,J)
      IF(N.EQ.0)GO TO 65
      IF(N.NE.N1)GO TO 63
      XL=XL+DIMX(J)
      GO TO 60
   63 IF(N1.NE.0)GO TO 67
      XL=DIMX(J)-THY(I,J)/2.-PLSTR(I,J)/2.
      IF(THY(I,J).EQ.0.)XL=XL-THY(I-1,J)/2.
      N1=N
      GO TO 60
   65 IF(N1.EQ.0)GO TO 60
      XL=XL-THY(I,J)/2.-PLSTR(I,J)/2.
      IF(THY(I,J).EQ.0.)XL=XL-THY(I-1,J)/2.
      SPAN(N1)=XL
      N1=0
      IF(XL.LT.SPMIN)SPMIN=XL
      XL=0.
      GO TO 60
   67 XL=XL-THY(I,J)/2.-PLSTR(I,J)/2.
      IF(THY(I,J).EQ.0.)XL=XL-THY(I-1,J)/2.
      SPAN(N1)=XL
      IF(XL.LT.SPMIN)SPMIN=XL
      XL=DIMX(J)-THY(I,J)/2.-PLSTR(I,J)/2.
      IF(THY(I,J).EQ.0.)XL=XL-THY(I-1,J)/2.
      N1=N
C NOTE THAT GRID LINES ARE ASSUMED CENTERED ON WALLS,I.E.,DIMX,DIMY
C MEASURED CENTER TO CENTER $
   60 CONTINUE
C CALC SPANS OF N-S WALLS $
      DO 70 J=1,NGX
      N1=0
      DO 70 I=1,NGY
      N=NWY(I,J)
      IF(N.EQ.0)GO TO 75
      IF(N.NE.N1)GO TO 73
      YL=YL+DIMY(I)
      GO TO 70
   73 IF(N1.NE.0)GO TO 74
      YL=DIMY(I)-THX(I,J)/2.-PLSTR(I,J)/2.
      IF(THX(I,J).EQ.0.)YL=YL-THX(I,J-1)/2.
      N1=N
      GO TO 70
   75 IF(N1.EQ.0)GO TO 70
      YL=YL-THX(I,J)/2.-PLSTR(I,J)/2.
      IF(THX(I,J).EQ.0.)YL=YL-THX(I,J-1)/2.
      SPAN(N1)=YL
```

```
      IF(SPMIN.GT.YL)SPMIN=YL
      N1=0
      YL=0
      GO TO 70
   74 YL=YL-THX(I,J)/2.-PLSTR(I,J)/2.
      IF(THX(I,J).EQ.0.)YL=YL-THX(I,J-1)/2.
      SPAN(N1)=YL
      IF(YL.LT.SPMIN)SPMIN=YL
      YL=DIMY(I)-THX(I,J)/2.-PLSTR(I,J)/2.
      IF(THX(I,J).EQ.0.)YL=YL-THX(I,J-1)/2.
      N1=N
   70 CONTINUE
C END CALC OF CLEAR SPANS OF WALLS $
C WRITE CLEAR SPANS OF ALL WALLS $
      WRITE(6,978)
  978 FORMAT(/25X,22HREG. WALL    CLEAR SPAN/28X,3HNO.,8X,7H(METER)//)
      DO 221 I=1,IUP
      M=NSR(I)
      IF(M.EQ.0)GO TO 221
      WRITE(6,979)M,SPAN(M)
  979 FORMAT(28X,I6,E13.4)
  221 CONTINUE
C CALCULATE CERTAIN PARAMETERS FOR EACH WALL FOR USE BY SUBROUTINE RESIST $
C MASS(NWALL)=MASS OF WALL NWALL W/O OPNG $
C AWALL(NWALL)=AREA OF WALL NWALL  W/O OPNG $
C AWIN(NWALL)=TOTAL AREA OF ALL OPNGS IN WALL NWALL $
C TAKE E-W WALLS FIRST $
      WRITE(6,990)
  990 FORMAT(/14H PROGRAM FLOOR/15X,9HREG. WALL,7X,4HMASS,9X,4HAREA,8X,
     14HOPNG,9X,4HOPNG,7X,4HOPNG/17X,3HNO.,11X,4H(KG),8X,6H(SQ.M)
     2,7X,4HAREA,9X,4HHGHT,7X,5HWIDTH/56X,6H(SQ.M),6X,7H(METER),5X,
     37H(METER)//)
      DO 460 I=1,NGY
      N1=0
      DO 460 J=1,NGX
      NWALL=NWX(I,J)
      IF((NWALL.EQ.0).OR.(NWALL.EQ.N1))GO TO 460
      N1=NWALL
      K=0
      AR=0.
      ZLVW1=0.
      ZLHW1=0.
      DO 461 II=1,NO
      IF(NOW(II).NE.NWALL)GO TO 461
      K=K+1
      AR=OAREA(II)+AR
      J1=JLOCO(II)
      ZLHW1=ZLHW1+DIMX(J1)
  461 CONTINUE
      IF(K.NE.0)ZLVW1=AR/ZLHW1
      ZLVW(NWALL)=ZLVW1
      ZLHW(NWALL)=ZLHW1
      AWALL(NWALL)=HGHT*SPAN(NWALL)-AR
      MASS(NWALL)=GAMMA(NWALL)*AWALL(NWALL)*TW(NWALL)
      AWIN(NWALL)=AR
      ZM=MASS(NWALL)
      AW=AWALL(NWALL)
      AW1=AWIN(NWALL)
      WRITE(6,991)NWALL,ZM,AW,AW1,ZLVW1,ZLHW1
  991 FORMAT(13X,I7,8X,5E12.4)
  460 CONTINUE
C NEXT TAKE N-S WALLS $
      DO 462 J=1,NGX
      N1=0
      DO 462 I=1,NGY
      NWALL=NWY(I,J)
      IF((NWALL.EQ.0).OR.(NWALL.EQ.N1))GO TO 462
      N1=NWALL
      K=0
      AR=0.
      ZLVW1=0.
      ZLHW1=0.
      DO 463 II=1,NO
      IF(NOW(II).NE.NWALL)GO TO 463
      AR=AR+OAREA(II)
      K=K+1
      I1=ILOCO(II)
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```
      ZLHW1=ZLHW1+DIMY(I1)
  463 CONTINUE
      IF(K.NE.0)ZLVW1=AR/ZLHW1
      ZLVW(NWALL)=ZLVW1
      ZLHW(NWALL)=ZLHW1
      AWIN(NWALL)=AR
      AWALL(NWALL)=HGHT*SPAN(NWALL)-AR
      MASS(NWALL)=GAMMA(NWALL)*AWALL(NWALL)*TW(NWALL)
      ZM=MASS(NWALL)
      AW=AWALL(NWALL)
      AW1=AWIN(NWALL)
      WRITE(6,991)NWALL,ZM,AW,AW1,ZLVW1,ZLHW1
  462 CONTINUE
C IF TRANSIT TIME FOR SHORTEST WALL .LT. DELT, WRITE WARNING & CONSIDER
C REDUCTION OF TMAX $
      IF((SPMIN/U).LT.DELT)WRITE(6,919)SPMIN,U,DELT
C BEGIN CALC OF BACKLOADING DELAY ON OUTSIDE WALLS $
C BLD(WALL NO.)=DELAY IN SECONDS $
C BACKLOADING BEGINS WHEN(TWAVE-BLD).EQ.0 $
C THEN BACKLOADING=ROOM PRESSURE $
C BLD=LEAST SHOCK TRAVEL TIME FROM OPNG TO WALL LESS(PLUS) TRAVEL TIME
C OF OUTSIDE BLAST BETWEEN OPNG & WALL $
C IF THERE IS AN OPNG IN OUTSIDE WALL ITSELF THEN BLD=0 $
C COMPUTE BLD FOR EACH OUTSIDE OPNG IN ROOM CONTAINING WALL, CHOOSE SMALLEST $
  919 FORMAT(/14H PROGRAM FLOOR/5X,38HTRANSIT TIME OF SHORTEST WALL .LT.
     1DELT/5X,13HSPMIN,U,DELT=,3E12.4//)
      IF(50.*DELT.GT.TMAX)GO TO 426
      TMAX1=50.*DELT
      WRITE(6,980)DELT,TMAX,TMAX1
  980 FORMAT(//14H PROGRAM FLOOR/5X,38HTMAX REDUCED TO MAKE ROOM IN PFAC,T
     1,TFAC/5X,14HDELT,OLD TMAX=,2E12.4/5X,9HNEW TMAX=,E12.4/)
      TMAX=TMAX1
  426 CONTINUE
C I=SPECIAL OUTSIDE WALL NO. $
C NWALL=OUTSIDE WALL NO. IN REGULAR SERIES $
C IHOLD(SPEC.OUT.WALL NO.)=OUTSIDE OPNG NO. WHERE OPNG CONTROLS
C BACKLOADING DELAY OF WALL $
C IHOLD=0 MEANS THERE IS NO BACKLOADING (I.E., NO OPNG) $
      DO 80 I=1,IUP
      NWALL=NSR(I)
      IF(NWALL.EQ.0)GO TO 80
      IHOLD(I)=0
      IK=ILOCWO(NWALL)
      JK=JLOCWO(NWALL)
C IF ROOM HAS NO OPNGS, BLD=1.E+70 $
      T2=1.E+70
C FETCH ROOM NO. FROM CORRELATION VECTOR $
      NRM=NWRO(NWALL)
C FIND ALL OUTSIDE OPNGS IN THIS ROOM $
      IF(NOO.EQ.0)GO TO 93
      DO 85 J=1,NOO
      NRM1=NORO(J)
      IF(NRM1.NE.NRM)GO TO 85
      II=ILOCOO(J)
      JJ=JLOCOO(J)
C CALC DISTANCE FROM OPNG TO WALL $ DX,DY ARE DIFFERENCES IN CARTESIAN COORDS $
C MAKE SURE DX AND DY HAVE CORRECT SIGNS $
      DX=0.
      DY=0.
      IF(II.EQ.IK)GO TO 222
      I1=MIN0(II,IK)
      I2=MAX0(II,IK)
      I21=I2-1
      DO 86 K=I1,I21
   86 DY=DIMY(K)+DY
      DY=DY*(II-IK)/(I2-I1)
  222 IF(JJ.EQ.JK)GO TO 223
      J1=MIN0(JJ,JK)
      J2=MAX0(JJ,JK)
      J21=J2-1
      DO 87 K=J1,J21
   87 DX=DIMX(K)+DX
      DX=DX*(JJ-JK)/(J2-J1)
  223 T1=SQRT(DX*DX+DY*DY)/U
      TEST=DX*CSA+DY*SNA
C IF TEST.GT.0 THEN OPNG IS DOWNSTREAM OF WALL $
C T1 IS CANDIDATE FOR BLD $ CHOOSE SMALLEST $
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  971 FORMAT(/14H PROGRAM FLOOR/5X,23HBACKLOADING DELAY .LT.0/5X,31HNO.R
     1OOM,NO.OPNG,BLD,DX,DY,TEST=,2I5,4E13.4//)
      T1=T1+TEST/U
      IF(T1.LT.0)WRITE(6,971)NRM1,J,T1,DX,DY,TEST
      IF(T1.GE.T2)GO TO 85
      T2=T1
      IHOLD(I)=J
   85 CONTINUE
   93 CONTINUE
      BLD(NWALL)=T2+DELAY
   80 CONTINUE
      WRITE(6,972)
      WRITE(6,940)
  972 FORMAT(//14H PROGRAM FLOOR)
      DO 90 I=1,IUP
      NWALL=NSR(I)
      IF(NWALL.EQ.0)GO TO 90
      NRM=NWRO(NWALL)
      J=IHOLD(I)
  940 FORMAT(2X,12HOUTSIDE WALL,2X,12HOUTSIDE OPNG,2X,8HROOM NO.,2X,11HB
     1ACKLOADING/3X,6HNUMBER,9X,6HNUMBER,19X,5HDELAY/1X,13HREG.  SPECIAL
     2//)
  945 FORMAT(I4,I7,I12,I10,E17.4)
      WRITE(6,945)NWALL,I,J,NRM,BLD(NWALL)
   90 CONTINUE
C END CALC OF BACKLOADING DELAYS $
      WRITE(6,955)
  955 FORMAT(/14H PROGRAM FLOOR//5X,30HLOADING DELAYS ON INSIDE WALLS//5
     1X,29HWALL      DELAY       I        J/6X,13HNO.      (SEC)//)
      N2=0
  956 FORMAT(4X,I5,E12.4,2I7)
C FIND LOADING DELAYS FOR INSIDE WALLS RELATIVE TO ARRIVAL OF EQUIV FRONT
C AT WALL AND STORE DELAY IN BLD $
      DO 300 I=1,NGY
C N=WALL NO. (REG.SERIES) $
      DO 300 J=1,NGX
      L1=.FALSE.
      N=NINX(I,J)
      IF((N.EQ.0).OR.(N.EQ.N2))GO TO 301
      N2=N
  315 T4=1.E+70
C FIND TWO ROOMS FOR THIS WALL $ FIND CLOSEST OPNG $
      KK=0
      DO 302 K=1,NRMS
      IF(NROOM(K,N).EQ.0)GO TO 302
      KK=KK+1
C K=ROOM NO. $
C FIND ALL OUTSIDE OPNGS IN THIS ROOM $
      IF(NOO.EQ.0)GO TO 94
      DO 303 II=1,NOO
C N1=ROOM NO.
      N1=NORO(II)
C II IS OUTSIDE OPNG NO. $
      IF(N1.NE.K)GO TO 303
C FIND DISTANCE FROM OPNG TO WALL $
      IK=ILOCOO(II)
      JK=JLOCOO(II)
      DX=0.
      DY=0.
      IF(I.EQ.IK)GO TO 225
      I1=MIN0(I,IK)
      I2=MAX0(I,IK)
      IUP1=I2-1
      DO 305 IJ=I1,IUP1
  305 DY=DY+DIMY(IJ)
      DY=DY*(IK-I)/(I2-I1)
  225 IF(J.EQ.JK)GO TO 226
      J1=MIN0(J,JK)
      J2=MAX0(J,JK)
      JUP=J2-1
      DO 306 IJ=J1,JUP
  306 DX=DX+DIMX(IJ)
      DX=DX*(JK-J)/(J2-J1)
  226 T1=SQRT(DX*DX+DY*DY)
      T3=DX*CSA+DY*SNA
      T2=(T1+T3)/U
      IF(T2.GE.0)GO TO 310
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      WRITE(6,952)I,J,DX,DY,T1,T3,II,N,K
  952 FORMAT(14H PROGRAM FLOOR/5X,10HERROR EXIT/5X,40HNEGATIVE BACKLOADI
     1NG DELAY ON INNER WALL/5X,16HI,J,DX,DY,T1,T3=,2I6,4E15.4/5X, 9HOPN
     2G NO.=,I6,2X, 9HWALL NO.=,I6,2X,9HROOM NO.=,I6/)
      CALL EXIT
  310 IF(T2.LT.T4)T4=T2
  303 CONTINUE
   94 CONTINUE
      IF(KK.LE.2)GO TO 302
      WRITE(6,953)I,J,N,K
  953 FORMAT(/25H PROGRAM FLOOR ERROR EXIT/5X,22HINSIDE WALL IN 3 ROOMS/
     15X,24HI,J,WALL NO.,3RD RM NO.=,4I6/)
      CALL EXIT
  302 CONTINUE
      T5=T4+DELAY
      BLD(N)=T5
      WRITE(6,956)N,T5,I,J
      IF(L1)GO TO 300
  301 N=NINY(I,J)
      IF((N.EQ.0).OR.(N.EQ.N2))GO TO 300
      N2=N
      L1=.TRUE.
      GO TO 315
C BEGIN CALC OF ARRIVAL TIMES AT OUTSIDE OPNGS, TOO,
C AND AT OUTSIDE WALLS, TWO $
C TRAVEL TIME MEASURED FROM GRID POINT (0,0) TO STORED LOCATION (I,J) $
C
  300 CONTINUE
      IF(NOO.EQ.0)GO TO 97
      DO 95  I=1,NOO
      II=ILOCOO(I)
      JJ=JLOCOO(I)
      DX=0.
      DY=0.
      IF(II.EQ.1)GO TO 427
      II1=II-1
      DO 91 J=1,II1
   91 DY=DY+DIMY(J)
  427 CONTINUE
      IF(JJ.EQ.1)GO TO 428
      JJ1=JJ-1
      DO 92 J=1,JJ1
   92 DX=DX+DIMX(J)
  428 CONTINUE
      TOO(I)=(DX*CSA+DY*SNA)/U
   95 CONTINUE
   97 CONTINUE
      DO 100 I=1,IUP
C I=OUTSIDE WALL NO. (SPECIAL SERIES) $
      N=NSR(I)
      IF(N.EQ.0)GO TO 100
C N=OUTSIDE WALL NO. (REGULAR SERIES) $
      II=ILOCWO(N)-1
      JJ=JLOCWO(N)-1
      DX=0.
      DY=0.
      IF(II.EQ.0)GO TO 429
      DO 101 J=1,II
  101 DY=DY+DIMY(J)
  429 CONTINUE
      IF(JJ.EQ.0)GO TO 435
      DO 102 J=1,JJ
  102 DX=DX+DIMX(J)
  435 CONTINUE
      TWO(N)=(DX*CSA+DY*SNA)/U
  100 CONTINUE
C FIND ARRIVAL TIMES OF EQUIVALENT FRONT AT INSIDE WALLS $
      DO 125 I=1,NGY
      I1=I-1
      N1=0
      DO 125 J=1,NGX
      J1=J-1
      N=NINX(I,J)
      IF((N.EQ.N1).OR.(N.EQ.0))GO TO 125
      DX=0.
      DY=0.
      IF(J.EQ.1)GO TO 436
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      DO 127 JJ=1,J1
  127 DX=DX+DIMX(JJ)
  436 IF(I.EQ.1)GO TO 432
      DO 128 JJ=1,I
  128 DY=DY+DIMY(JJ)
  432 N1=N
      TWI(N)=(DX*CSA+DY*SNA)/U
  125 CONTINUE
      DO 129 J=1,NGX
      J1=J-1
      N1=0
      DO 129 I=1,NGY
      I1=I-1
      N=NINY(I,J)
      IF((N.EQ.N1).OR.(N.EQ.0))GO TO 129
      DX=0.
      DY=0.
      IF(J.EQ.1)GO TO 433
      DO 126 JJ=1,J1
  126 DX=DX+DIMX(JJ)
  433 IF(I.EQ.1)GO TO 434
      DO 124 JJ=1,I1
  124 DY=DY+DIMY(JJ)
  434 CONTINUE
      N1=N
      TWI(N)=(DX*CSA+DY*SNA)/U
  129 CONTINUE
C PRINT OUT ARRIVAL TIMES $
      WRITE(6,966)
  966 FORMAT(/14H PROGRAM FLOOR//20X,13HARRIVAL TIMES//15X,24HOUTSIDE OP
     1NG   TIME(SEC)/17X,10HNO.(SPEC.)/)
      IF(NOO.EQ.0)GO TO 98
      DO 446 I=1,NOO
  446 WRITE(6,964)I,TOO(I)
   98 CONTINUE
      WRITE(6,965)
  965 FORMAT(/15X,24HOUTSIDE WALL    TIME(SEC)/16X,9HNO.(REG.)/)
      DO 447 I=1,IUP
      N=NSR(I)
      IF(N.EQ.0)GO TO 447
      WRITE(6,964)N,TWO(N)
  447 CONTINUE
  964 FORMAT(15X,I7,5X,E11.4)
      DO 52 I=1,10
      DO 52 J=1,50
      PFAC(I,J)=0.
      TFAC(I,J)=0.
   52 CONTINUE
C CALCULATE EXT. PRESSURE HISTORIES AGAINST OUTSIDE WALLS $
C MAKE ONE CALL TO SUBROUTINE POUT FOR EACH OUTSIDE WALL $
      DO 50 I=1,IUP
C N=REGULAR SEQ. NO. OF OUTSIDE WALL I $
      N=NSR(I)
      IF(N.EQ.0)GO TO 50
      CALL POUT(N,V1,V2)
      DO 51 J=1,50
C VECTORS V1,V2 TEMPORARILY STORE PRESS. & TIME VALUES $
C PROVIDE FOR MAX. OF 50 PAIRS OF PRESS.,TIME IN V1,V2 $
C MATRICES PFAC(WALL NO.,J),TFAC(WALL NO.,J) PROVIDE PERMANENT LOCATIONS
C FOR PRESSURE HISTORIES $ SPECIAL SEQ. OUTSIDE WALL NOS USED TO REDUCE
C REQUIRED STORAGE $
      PFAC(I,J)=V1(J)
      TFAC(I,J)=V2(J)
   51 CONTINUE
   50 CONTINUE
C END CALC OF ARRIVAL TIMES $
C IF THIS IS A REORGANIZATION,I.E.,AN OUTSIDE WALL HAS FAILED, ROOM PRESSURES,
C PRM, AND DENSITIES, RHORM, HAVE ALREADY BEEN TRANSFERRED TO NEW ROOM NOS. $
C ON REORGANIZATION WALLS ARE      RENUMBERED AND   ERASED FROM INTERSECTION
C MATRICES $
C DEFLECTION OF FAILED OUTSIDE WALLS SET TO 1.E+70 $
      IF(FAILO)GO TO 121
      DO 110 I=1,NRMS
      PRM(I)=PO
  110 RHORM(I)=RHOO
      GO TO 122
  121 DO 412 I=1,50
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      V1(I)=0.
  412 V2(I)=0.
      K=0
C IF THIS IS A REORGANIZATION FIND OLD ROOM NOS CORRESPONDING TO
C NEW NOS AND TRANSFER PRESSURES AND DENSITIES $
C K COUNTS NO. OF NE CORNERS $
      DO 410 I=1,NGY
      DO 410 J=1,NGX
      IF(NE(I,J).EQ.0)GO TO 410
      K=K+1
      N2=NE(I,J)
      N1=NEO(I,J)
      V1(N2)=PRM(N1)
      PRM(N1)=0.
      V2(N2)=RHORM(N1)
      RHORM(N1)=0.
  410 CONTINUE
      DO 411 I=1,NRMS
      PRM(I)=V1(I)
  411 RHORM(I)=V2(I)
C NO. NE CORNERS SHOULD EQUAL NO. OF ROOMS $
      IF(K.EQ.NRMS)GO TO 122
      WRITE(6,973)K,NRMS,TIME
  973 FORMAT(14H PROGRAM FLOOR/5X,10HERROR EXIT/5X,46HNE CORNERS DONT EQ
     1UAL NO. OF ROOMS AFTER REORG/5X,12HK,NRMS,TIME=,2I6,E12.4)
      CALL EXIT
  122 FAILO=.FALSE.
      FAILI=.FALSE.
C ON BOTH INITIAL PASS AND ON REORGANIZATION INITIALIZE WALL PARAMETERS
C IN SUBROUTINE RESIST $
      DO 465 I=1,NW1
      NWALL=2*I
      Y=0.
      CALL RESIST(NWALL,Y,Q,1)
  465 CONTINUE
      DO 466 I=1,NW2
      NWALL=2*I-1
      Y=0.
      CALL RESIST(NWALL,Y,Q,1)
  466 CONTINUE
C
C BEGIN TIME LOOP $
C
  120 TIME=TIME+DELT
      WRITE(6,9000)TIME
 9000 FORMAT(/25X,5HTIME=,E12.4/)
C
C BEGIN OUTSIDE OPNG LOOP $
C
      IF(NOO.EQ.0)GO TO 99
      DO 210 I=1,NOO
      TWAVE=TIME-TOO(I)
      IF(TWAVE-DELAY)210,211,211
  211 NRM=NORO(I)
      PINT=PRM(NRM)
      OA  =OOAREA(I)
      RHO3=RHORM(NRM)
      VOL=HGHT*AREA(NRM)
C NWALL=OUTSIDE WALL NO. IN REGULAR SERIES $
      NWALL=NOWO(I)
C FIND SPECIAL OUTSIDE WALL NO. J0 $
      DO 213 J=1,IUP
      N=NSR(J)
      IF(N.EQ.0)GO TO 213
      J0=J
      IF(N.EQ.NWALL)GO TO 214
  213 CONTINUE
  214 CONTINUE
C FIND CURRENT OUTSIDE PRESSURE AT WALL CONTAINING THIS OPNG $
      DO 212 J=1,100
      J00=J
      IF(TWAVE.LE.TFAC(J0,J))GO TO 215
  212 CONTINUE
      WRITE(6,946)I,NWALL,TWAVE
  946 FORMAT(/25H PROGRAM FLOOR ERROR EXIT/5X,14HI,NWALL,TWAVE=,2I6,E15.
     14/)
      CALL EXIT
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  215 T2=TFAC(J0,J00)
      J1=J00-1
      T1=TFAC(J0,J1)
      P2=PFAC(J0,J00)
      P1=PFAC(J0,J1)
C INTERPOLATE FOR OUTSIDE OVERPRESSURE AND CONVERT TO ABSOLUTE SCALE $
      PEXT=P1+(P2-P1)*(TWAVE-T1)/(T2-T1)+PO
      CALL FLOW(PINT,PEXT,RHO3,OA,VOL,XMASS,W,OUTFLW)
C XMASS=MASS INCREMENT THRU THIS OUTSIDE OPNG IN THIS TIME INTERVAL $
C W=ENERGY INCREMENT $
C MASS ACCUMULATED IN DELM(RM NO.), ENERGY IN DELW(RM NO.) $
      IF(OUTFLW)WRITE(6,992)I,NWALL,NRM
  992 FORMAT(/5X,36HOUTFLOW AT (SPEC.) OUTSIDE OPNG NO.=,I6,2X,
     119HIN WALL NO. (REG.)=,I6,2X,9HROOM NO.=,I6/)
      DELM(NRM)=DELM(NRM)+XMASS
      DELW(NRM)=DELW(NRM)+W
  210 CONTINUE
   99 CONTINUE
C END OUTSIDE OPNG LOOP $
C UPDATE OUTSIDE ROOM PRESSURES AND DENSITIES $
      DO 220 I=1,NRMS
C IF ROOM HAS BEEN ABOLISHED DUE TO INTERIOR WALL FAILURE, SKIP UPDATE $
      IF(PRM(I).EQ.0.)GO TO 220
      VOL=HGHT*AREA(I)
      PRM(I)=PRM(I)+DELW(I)*(G-1.)/VOL
      DELW(I)=0.
      RHORM(I)=RHORM(I)+DELM(I)/VOL
      DELM(I)=0.
  220 CONTINUE
C BEGIN OUTSIDE WALL LOOP $
C NWALL=OUTSIDE WALL NO. IN REGULAR SERIES $
C I=SPECIAL OUTSIDE WALL NO. $
      DO 250 I=1,IUP
      NWALL=NSR(I)
      IF(NWALL.EQ.0)GO TO 250
      IF(TFAIL(NWALL).LT.1.E+10)GO TO 456
      TWAVE=TIME-TWO(NWALL)
      IF(TWAVE.LT.0)GO TO 250
C FIND CURRENT OUTSIDE PRESSURE AT THIS WALL $
      DO 252 J=1,100
      J0=J
      IF(TWAVE.GE.TFAC(I,J))GO TO 255
  252 CONTINUE
      WRITE(6,947)I,TWAVE
  947 FORMAT(/25H PROGRAM FLOOR ERROR EXIT/5X,14HCANT FIND TFAC/5X,15HWA
     1LL NO.,TWAVE=,I6,E15.4/)
      CALL EXIT
  255 P1=PFAC(I,J0)
      J1=J0+1
      P2=PFAC(I,J1)
      T1=TFAC(I,J0)
      T2=TFAC(I,J1)
      PEXT=P1+(P2-P1)*(TWAVE-T1)/(T2-T1)+PO
C IF WAVE TIME IS LESS THAN BACKLOADING DELAY INSIDE PRESSURE=ZERO $
      IF(TWAVE-BLD(NWALL))257,258,258
  257 PINT=PO
      GO TO 259
  258 NRM=NWRO(NWALL)
      PINT=PRM(NRM)
C
  259 CALL WALL(NWALL,PEXT,PINT,FAIL,OUT)
C
      IF(.NOT.FAIL)GO TO 456
C WHEN OUTSIDE WALL FAILS, DELAY ITS REMOVAL TO ALLOW ROOM TO FILL $
C OUT=.TRUE. MEANS WALL HAS FAILED OUTWARD $
      DLY=SQRT(AREA(NRM))/U
      TFAIL(NWALL)=TIME+DLY
      IF(OUT)GO TO 454
      WRITE(6,983)NWALL
  983 FORMAT(/5X,16HWALL NO. (REG.)=,I6,2X,12HFAILS INWARD/)
      GO TO 458
  454 WRITE(6,984)NWALL
  984 FORMAT(/5X,16HWALL NO. (REG.)=,I6,2X,13HFAILS OUTWARD/)
  458 CONTINUE
C CHECK TO SEE IF THIS OUTSIDE WALL SHOULD BE REMOVED AT THIS TIME $
  456 IF(TIME.LT.TFAIL(NWALL))GO TO 250
      FAILO=.TRUE.
```

```
C ERASE ENTRIES IN INTERSECTION MATRICES FOR FAILED OUTSIDE WALL $
      JJ=JLOCWO(NWALL)
      II=ILOCWO(NWALL)
      IF(MOD(NWALL,2))260,260,261
C NEED REMOVE ONLY ONE SEGMENT OF OUTSIDE WALL; REMAINDER IS
C HANGING WALL WHICH IS REMOVED ON REORGANIZATION $
  260 NX(II,JJ)=0
      NXX(NRM,II,JJ)=0
      THX(II,JJ)=0
      GO TO 250
  261 NY(II,JJ)=0
      NYY(NRM,II,JJ)=0
      THY(II,JJ)=0
  250 CONTINUE
C
C BEGIN INSIDE WALL LOOP $
C
      DO 280 I=1,NGY
      N0=0
      DO 280 J=1,NGX
C FIND INSIDE WALL NO. N  $
      L1=.FALSE.
      N=NINX(I,J)
      IF((N.EQ.0).OR.(N.EQ.N0))GO TO 281
      N0=N
  284 TEST=TIME-TWI(N)-TFAIL(N)-BLD(N)
      IF((TEST.LT.0).AND.(.NOT.L1))GO TO 281
      IF(TEST.LT.0)GO TO 280
      FAILI=.TRUE.
C KK COUNTS ROOMS CONTAINING FAILED WALL $
      KK=0
      DO 285 K=1,NRMS
      N1=NROOM(K,N)
      IF(N1.EQ.0)GO TO 285
      KK=KK+1
C REMOVE FAILED INSIDE WALL FROM NROOM $
      NROOM(K,N)=0
      IHOLD(KK)=K
  285 CONTINUE
C COMBINE PRESSURES AND DENSITIES IN ROOMS SEPARATED BY FAILED WALL $
C SMALLER ROOM NO. BECOMES NO. OF COMBINED ROOM $
C NEW ROOM GRID POINT IS MOST SOUTHERLY AND MOST WESTERLY ON THAT ROW $
C NEWR=NEW ROOM NO. $
      NEWR=IHOLD(1)
C REMOVE FAILED INSIDE WALL FROM INTERSECTION MATRICES:
C   NX,NY,NXX,NYY,THX,THY,NWX,NWY,NINX,NINY
      IF(.NOT.L1)GO TO 290
C MUST REMOVE ALL SEGMENTS OF FAILED INTERIOR WALL $
      DO 441 I1=I,10
      N1=NINY(I1,J)
      IF(N.NE.N1)GO TO 292
      NINY(I1,J)=0
      NWY(I1,J)=0
      THY(I1,J)=0
      NY(I1,J)=0
      DO 291 K=1,KK
      NRM=IHOLD(K)
  291 NYY(NRM,I1,J)=0
  441 CONTINUE
      GO TO 292
  290 DO 443 J1=J,10
      N1=NINX(I,J1)
      IF(N.NE.N1)GO TO 292
      NINX(I,J1)=0
      NWX(I,J1)=0
      THX(I,J1)=0
      NX(I,J1)=0
      DO 294 K=1,KK
      NRM=IHOLD(K)
  294 NXX(NRM,I,J1)=0
  443 CONTINUE
  292 CONTINUE
C FOR INSIDE WALLS THERE IS ONLY ONE CORRELATION MATRIX, NROOM $
C PUT NEW ROOM NO. IN NROOM AND IN NXX & NYY AND IN NORO $
      DO 295 K=2,KK
      NR=IHOLD(K)
      DO 296 KW=1,NW
```

```
      IF(NROOM(NR,KW).EQ.0)GO TO 296
      NROOM(NR,KW)=0
      NROOM(NEWR,KW)=1
  296 CONTINUE
C PUT NEW ROOM NO. IN OUTSIDE OPNG CORRELATION MATRIX NORO $
      IF(NOO.EQ.0)GO TO 405
      DO 403 KO=1,NOO
      IF(NORO(KO).NE.NR)GO TO 403
      NORO(KO)=NEWR
  403 CONTINUE
  405 CONTINUE
C ENTER NEW ROOM NO. IN CORRELATION WITH OUTSIDE WALL NOS $
      DO 404 KWO=1,IUP
      N1=NSR(KWO)
      IF(N1.EQ.0)GO TO 404
      IF(JRM(KWO).NE.NR)GO TO 404
      NWRO(N1)=NEWR
      JRM(KWO)=NEWR
  404 CONTINUE
      IF(L1)GO TO 297
      DO 298 IK=1,NGY
      DO 298 JK=1,NGX
      IF(NXX(NR,IK,JK).EQ.0)GO TO 298
      NXX(NR,IK,JK)=0
      NXX(NEWR,IK,JK)=1
  298 CONTINUE
      GO TO 295
  297 DO 299 IK=1,NGY
      DO 299 JK=1,NGX
      IF(NYY(NR,IK,JK).EQ.0)GO TO 299
      NYY(NR,IK,JK)=0
      NYY(NEWR,IK,JK)=1
  299 CONTINUE
  295 CONTINUE
C
C FIND NO. OF COMBINED ROOM AND ENTER IN:
C    NE,AREA,PRM,RHORM
C
      II0=NGY
      XM=0.
      A=0.
      T=0.
      IF(KK.EQ.2)GO TO 286
      WRITE(6,957)I,J,N,KK,L1
  957 FORMAT(25H PROGRAM FLOOR ERROR EXIT/5X,29HTOO MANY ROOMS AT INSIDE
     1 WALL/5X, 7HCOORDS=,2I6,2X,9HWALL NO.=,I6,2X,10HNO. ROOMS=,I6/5X,3
     2HL1=,L2/)
      CALL EXIT
C N2=NO. OF ONE OF COMBINED ROOMS $
  286 DO 287 K=1,KK
      N2=IHOLD(K)
      DO 430 III=1,NGY
      DO 430 JJJ=1,NGX
      IF(NE(III,JJJ).EQ.N2)GO TO 431
  430 CONTINUE
      WRITE(6,974)I,J,N2
  974 FORMAT(14H PROGRAM FLOOR/5X,10HERROR EXIT/5X,57HCANT COMBINE ROOMS
     1SEPARATED BY FAILED INSIDE WALL AT I,J=,2I6/5X,26HNO NE CORNER FOR
     2 ROOM NO.=,I6)
      CALL EXIT
  431 II=III
      JJ=JJJ
      NE(II,JJ)=0
      A1=AREA(N2)
      AREA(N2)=0.
      IF(II.GT.II0)GO TO 288
      IF(II.NE.II0)GO TO 289
      IF(JJ.LT.JJ0)JJ0=JJ
      GO TO 288
  289 II0=II
      JJ0=JJ
  288 CONTINUE
      T1=PRM(N2)/RHORM(N2)
      PRM(N2)=0.
      XM1=RHORM(N2)*A1*HGHT
      RHORM(N2)=0.
      XM2=XM
```

```
      XM=XM+XM1
      T=(T1*XM1+T*XM2)/XM
      A=A+A1
C T=TEMPERATURE*RMW, WHERE RMW=GAS CONSTANT/MOLECULAR WT $
  287 CONTINUE
C ASSIGN NEW ROOM NO. TO MORE SOUTHWESTERLY CORNER OF THE TWO NE CORNERS $
      NE(II0,JJ0)=NEWR
      VOL=A*HGHT
      RHO=XM/VOL
      PRM(NEWR)=RHO*T
      RHORM(NEWR)=RHO
      AREA(NEWR)=A
      IF(L1)GO TO 280
  281 N=NINY(I,J)
      IF((N.EQ.0).OR.(N.EQ.N0))GO TO 280
      N0=N
      L1=.TRUE.
      GO TO 284
  280 CONTINUE
C
C END OF INSIDE WALL LOOP $
C
C IF MAX TIME REACHED, QUIT AND PRINTOUT RESULTS $
      IF(TIME.GE.TMAX)GO TO 400
C
C IF THERE HAS BEEN OUTER WALL FAILURE, RETURN TO SUBROUTINE CORNER
C AND REORGANIZE $
C COPY NE(I,J) ONTO NEO(I,J) TO MAKE TRANSFER OF PRESSURE AND DENSITIES TO
C REORGANIZED ROOMS $
      IF(.NOT.FAILO)GO TO 120
      DO 351 I=1,NGY
      DO 351 J=1,NGX
  351 NEO(I,J)=NE(I,J)
      GO TO 500
C PRINT RESULTS $
  400 WRITE(6,960)TIME
  960 FORMAT(///14H PROGRAM FLOOR/5X,13HENDS AT TIME=,E11.4,7H  (SEC)///
     125X,29HFINAL E-W INTERSECTION MATRIX//)
      DO 401 I=1,NGY
      WRITE(6,961)I
  961 FORMAT(/5X,4HROW=,I4)
      WRITE(6,962)(NX(I,J),J=1,NGX)
  962 FORMAT( 10X,20I3)
  401 CONTINUE
      WRITE(6,963)
  963 FORMAT(///25X,29HFINAL N-S INTERSECTION MATRIX//)
      DO 402 I=1,NGY
      WRITE(6,961)I
      WRITE(6,962)(NY(I,J),J=1,NGX)
  402 CONTINUE
      IF(.NOT.FAILI)GO TO 512
      CALL CORNER
      GO TO 513
  512 WRITE(6,981)
  981 FORMAT(/14H PROGRAM FLOOR//22X,16HKINDS OF CORNERS//)
      DO 455 I=1,NGY
  455 WRITE(6,982)(KIND(I,J),J=1,NGX)
  982 FORMAT(/5X,12(I4,1X))
  513 WRITE(6,987)
  987 FORMAT(///14H PROGRAM FLOOR//10X,8HWALL NO.,11X,4HDEFL,12X,3HVEL,10X
     1X,5HACCEL/11X,6H(REG.),10X,7H(METER),7X,11H(METER/SEC),3X,12H(METE
     2R/SEC2)//)
      DO 510 I=1,NW1
      II=2*I
      DE=DEFL(II)
      DE=DEFL(II)
      VE=VEL(II)
      AC=ACCEL(II)
  510 WRITE(6,988)II,DE,VE,AC
  988 FORMAT(10X,I8,3X,3E15.4)
      DO 511 I=1,NW2
      II=2*I-1
      VE=VEL(II)
      AC=ACCEL(II)
      DE=DEFL(II)
  511 WRITE(6,988)II,DE,VE,AC
      CALL EXIT
```

```
      RETURN
C     END PROGRAM FLOOR $
      END
      SUBROUTINE TRACE(I0,J0,NRM,A)
C CREATES INTERSECTION MATRICES NXX,NYY FOR ROOM NO. NRM CONTAINING
C NE CORNER AT (I0,J0) $ ALSO COMPUTES ROOM AREA A AND ENTERS WALL
C NOS. IN CORRELATION MATRIX NROOM $
C NROOM(NRM,NO.WALL)=1 IF WALL IS IN ROOM NRM. OTHERWISE NROOM=0 $
C REQUIRES MATRIX KIND(I,J) CONTAINING ALPHABETIC CORNER DESCRIPTIONS
C AT GRID POINTS (I,J) $ GRID PTS W/O CORNERS ARE ZERO $
      COMMON /RMS/ NROOM(10,100),AREA(10),PRM(10),RHORM(10),NRMS
      COMMON /CRNR/ KIND(20,20),NE(20,20),PLSTR(20,20)
      COMMON /GRID/ NX(20,20),NY(20,20),                        NXX(10,20,
     120),NYY(10,20,20),DIMX(20),DIMY(20),NX0(20,20),NY0(20,20),NGX,NGY
      COMMON /WAND/ NWX(20,20),NWY(20,20)
      LOGICAL ISOUTH,LE
      LOGICAL LNORTH,LSOUTH,LEAST,LWEST
      LNORTH(I)=(I.EQ.1000).OR.(I.EQ.1100).OR.(I.EQ.1010).OR.(I.EQ.1001
     1).OR.(I.EQ.1110).OR.(I.EQ.1011).OR.(I.EQ.1101).OR.(I.EQ.1111)
      LSOUTH(I)=(I.EQ.0100).OR.(I.EQ.1100).OR.(I.EQ.0110).OR.(I.EQ.0101
     1).OR.(I.EQ.1110).OR.(I.EQ.0111).OR.(I.EQ.1101).OR.(I.EQ.1111)
      LEAST(I)=(I.EQ.0010).OR.(I.EQ.1010).OR.(I.EQ.0110).OR.(I.EQ.0011)
     1.OR.(I.EQ.1110).OR.(I.EQ.0111).OR.(I.EQ.1011).OR.(I.EQ.1111)
      LWEST(I)=(I.EQ.0001).OR.(I.EQ.1001).OR.(I.EQ.0101).OR.(I.EQ.0011)
     1.OR.(I.EQ.1101).OR.(I.EQ.0111).OR.(I.EQ.1011).OR.(I.EQ.1111)
C NXX & NYY ARE SAME SIZE AS NX & NY $
      DO 1 I=1,NGY
      DO 1 J=1,NGX
      NXX(NRM,I,J)=0
      NYY(NRM,I,J)=0
    1 CONTINUE
      DO 2 I=1,100
    2 NROOM(NRM,I)=0
      JMAX=J0
      IMAX=I0
      IMIN=I0
      JMIN=J0
      A=0.
      ISOUTH=.FALSE.
      IK=0
      IT=0
      ICW=0
C IK COUNTS WALLS IN ROOM DURING MATRIX CONSTRUCTION FOR LATER CHECK $
C IT COUNTS NO. OF ATTEMPTS TO FIND TRACE $ ALLOW NO MORE THAN 3 $
C CHECK THAT STARTING GRID POINT IS NORTHEAST $ IF SO, GO EAST $
      K=KIND(I0,J0)
      I=I0
      J=J0
      IF(LNORTH(K).AND.LEAST(K))GO TO 27
      WRITE(6,900)NRM,K,I0,J0
  900 FORMAT(17H SUBROUTINE TRACE/5X,10HERROR EXIT/5X,9HROOM NO.=,I6,2X,
     127HDOES NOT START AT NE CORNER/5X,5HKIND=,A4,2X,6HI0,J0=,2I6//)
      CALL EXIT
C TRY TO GO EAST $ IF NOT, TRY SOUTH $
   10 IT=IT+1
      IF(IT.GT.3)GO TO 65
      K=KIND(I,J)
      IF(.NOT.LEAST(K))GO TO 15
C AT EVERY CHANGE OF DIRECTION CHECK TO SEE IF CHANGE IS CW OR CCW $
C FOR CCW ADD 1 TO ICW $ FOR CW ADD -1 $ DISCARD ROOM IF TOTAL NOT +3 $
C THE ATTEMPT SEQUENCE DEPENDS ON IMMED. PRECEEDING DIRECTION :
C     FROM NORTH, TRY W,N THEN E
C     FROM SOUTH, TRY E,S THEN W
C     FROM EAST, TRY N,E THEN S
C     FROM WEST, TRY S,W THEN N
C IT=2 MEANS NO DIRECTION CHANGE $
C GO EAST $
      IF(IT-2)26,27,28
   26 ICW=ICW+1
      GO TO 27
   28 ICW=ICW-1
   27 IT=0
      IK=IK+1
      N=NWX(I,J)
      NROOM(NRM,N)=1
C ANY NE CORNER IN THIS ROOM TRACED OUT SOUTH TO EAST (EXCEPT DEFINING
C CORNER AT I0,J0) MUST BE CANCELLED IN MATRIX NE, WHICH WILL FINALLY
```

```
C CONTAIN ONE NE CORNER IN EACH ROOM $
      IF(.NOT.ISOUTH)GO TO 21
      NE(I,J)=0
      ISOUTH=.FALSE.
   21 J=J+1
C FIND NEXT CORNER TO THE EAST
C WALL NO. IS ASSOCIATED WITH START GRID POINT THRU MATRIX NWX OR NWY
      IF(J.GT.NGX)GO TO 500
C FILL INTERSECTION MATRIX FOR THIS ROOM WITH EVERY WALL SEGMENT
      NXX(NRM,I,J-1)=1
      IF(KIND(I,J).EQ.0)GO TO 21
      IF(JMAX.LT.J)JMAX=J
C TRY TO GO NORTH $ IF NOT, TRY EAST $
   35 IT=IT+1
      IF(IT.GT.3)GO TO 65
      K=KIND(I,J)
      IF(.NOT.LNORTH(K))GO TO 10
C GO NORTH $
      IF(IT-2)46,47,48
   46 ICW=ICW+1
      GO TO 47
   48 ICW=ICW-1
   47 IT=0
      IK=IK+1
      N=NWY(I,J)
      NROOM(NRM,N)=1
   52 I=I+1
      IF(I.GT.NGY)GO TO 500
      NYY(NRM,I-1,J)=1
      IF(KIND(I,J).EQ.0)GO TO 52
      ISOUTH=.FALSE.
      IF(I.GT.IMAX)IMAX=I
C TRY WEST $ IF NOT,TRY NORTH $
   40 IT=IT+1
      IF(IT.GT.3)GO TO 65
      K=KIND(I,J)
      IF(.NOT.LWEST(K))GO TO 35
C GO WEST $
   54 J=J-1
      IF(J.LT.1)GO TO 500
      NXX(NRM,I,J)=1
      IF(KIND(I,J).EQ.0)GO TO 54
      N=NWX(I,J)
      NROOM(NRM,N)=1
      IF(IT-2)41,42,43
   41 ICW=ICW+1
      GO TO 42
   43 ICW=ICW-1
   42 IT=0
      IK=IK+1
      ISOUTH=.FALSE.
      IF(J.LT.JMIN)JMIN=J
C TRY SOUTH $ IF NOT TRY WEST $
   15 IT=IT+1
      IF(IT.GT.3)GO TO 65
      K=KIND(I,J)
      IF(.NOT.LSOUTH(K))GO TO 40
C GO SOUTH $
   55 I=I-1
      IF(I.LT.1)GO TO 500
      NYY(NRM,I,J)=1
      IF(KIND(I,J).EQ.0)GO TO 55
      N=NWY(I,J)
      NROOM(NRM,N)=1
      IF(IT-2)31,32,33
   31 ICW=ICW+1
      GO TO 32
   33 ICW=ICW-1
   32 IT=0
      IK=IK+1
      ISOUTH=.TRUE.
      IF(I.LT.IMIN)IMIN=I
C CHECK FOR POSSIBLE RETURN TO STARTING POINT $
      IF((I0.EQ.I).AND.(J0.EQ.J))GO TO 60
C TRY EAST $
      GO TO 10
C ERROR EXIT FOR MORE THAN 3 TRIES TO FIND PATH $
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```
   65 WRITE(6,901)NRM,IK,I0,J0,I,J
  901 FORMAT(/17H SUBROUTINE TRACE/5X,10HERROR EXIT/5X,30HMORE THAN 3 TR
     1IES IN ROOM NO.=,I6,2X,25HNO. WALLS COUNTED SO FAR=,I6/5X,15HSTART
     2ING POINT=,2I6,2X,13HENDING POINT=,2I6//)
      CALL EXIT
C CHECK FOR CLOCKWISE TRACE $ IF SO, DISCARD ROOM $
   60 IF(ICW.EQ.3)GO TO 61
      WRITE(6,902)NRM,I0,J0
  902 FORMAT(/17H SUBROUTINE TRACE/5X,26HCIRCUIT IN WRONG DIRECTION/5X,9
     1HROOM NO.=,I4,2X,9HAT I0,J0=,2I4,2X,11HNOT COUNTED/)
      NE(I0,J0)=0
      DO 62 I=1,NGY
      DO 62 J=1,NGX
      NXX(NRM,I,J)=0
      NYY(NRM,I,J)=0
   62 CONTINUE
      DO 63 I=1,100
   63 NROOM(NRM,I)=0
      RETURN
C COMPUTE AREA OF ROOM FROM BOTH NXX AND NYY AND COMPARE RESULTS $
C NW COUNTS WALLS FOR CHECK WITH IK $
   61 K1=0
      NW=0
      DO 95 J=JMIN,JMAX
      K=0
      LE=.FALSE.
      DO 95 I=IMIN,IMAX
      N=NXX(NRM,I,J)
      IF(.NOT.LE)GO TO 96
      K=K+1
      A=A+DIMY(I-1)*DIMX(J)
   96 IF(N.EQ.0)GO TO 95
      NW=NW+1
      IF(.NOT.LE)GO TO 110
      K1=K1+K
      LE=.FALSE.
      K=0
      GO TO 95
  110 LE=.TRUE.
   95 CONTINUE
      K2=0
      DO 115 I=IMIN,IMAX
      K=0
      LE=.FALSE.
      DO 115 J=JMIN,JMAX
      N=NYY(NRM,I,J)
      IF(LE)K=K+1
      IF(N.EQ.0)GO TO 115
      NW=NW+1
      IF(.NOT.LE)GO TO 130
      K2=K2+K
      K=0
      LE=.FALSE.
      GO TO 115
  130 LE=.TRUE.
  115 CONTINUE
C COMPARE TWO VALUES FOR NO. OF GRID SQUARES $
      IF(K1.EQ.K2)GO TO 140
      WRITE(6,905)NRM,I0,J0,IMIN,IMAX,JMIN,JMAX,K1,K2
  905 FORMAT(/17H SUBROUTINE TRACE/5X,10HERROR EXIT/5X,9HROOM NO.=,I6/5X
     1,26HI0,J0,IMIN,IMAX,JMIN,JMAX=,6I6/5X,6HXAREA=,I6,2X,6HYAREA=,I6,2
     2X,10HGRID UNITS//)
      CALL EXIT
  500 WRITE(6,906)NRM,I0,J0,I,J
  906 FORMAT(/17H SUBROUTINE TRACE/5X,10HERROR EXIT/5X,12HRAN OFF GRID
     1,5X,9HROOM NO.=,I6/5X,12HSTART POINT=,2I6,2X,10HEND POINT=,
     22I6/)
      CALL EXIT
  140 CONTINUE
      WRITE(6,903)NRM,I0,J0,IMIN,IMAX,JMIN,JMAX,IK,NW
      NW=IK
  903 FORMAT(/17H SUBROUTINE TRACE/5X,9HROOM NO.=,I6/5X
     1,26HI0,J0,IMIN,IMAX,JMIN,JMAX=,6I6/5X,10HNO. WALLS=,I6,
     22X,18HNO. WALL SEGMENTS=,I6)
  150 WRITE(6,904)K1,A
  904 FORMAT(5X,5HAREA=,I6,2X,
     110HGRID UNITS,2X,1H=,E11.4,2X,9HSQ METERS/)
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```
          WRITE(6,907)
      907 FORMAT(5X,15HWALL NOS (REG.)/)
          DO 141 I=1,100
          J=NROOM(NRM,I)
          IF(J.EQ.0)GO TO 141
          WRITE(6,908)I
      908 FORMAT(10X,I6)
      141 CONTINUE
          RETURN
C END TRACE
          END
C
C
          SUBROUTINE CORNER
C FROM THE TWO INTERSECTION MATRICES NX AND NY OF A FLOOR SUBROUTINE CORNER
C CONSTRUCTS MATRIX KIND(I,J) GIVING GRID LOCATIONS AND DESCRIPTION OF EACH
C WALL INTERSECTION $
C DESCRIPTION IS FOUR-CHARACTER, RIGHT JUSTIFIED ALPHABETIC STRING, E.G.,
C 4RN E  DESCRIBES CORNER FROM WHICH 2 WALLS EMERGE, ONE GOING NORTH,
C ONE EAST $ DIRECTIONS OCCUPY FIXED  ORDER IN STRING: NORTH,SOUTH,EAST,WEST $
C REMAINDER OF WORD ZERO FILLED $
C SUBROUTINE CORNER ALSO ASSIGNS WALL NOS. TO MATRICES NWX & NWY $
          COMMON /CRNR/ KIND(20,20),NE(20,20),PLSTR(20,20)
          COMMON /GRID/ NX(20,20),NY(20,20),NXX(10,20,20),NYY(10,20,20),
         1                    DIMX(20),DIMY(20),NXO(20,20),NYO(20,20),NGX,NGY
          COMMON /WAND/ NWX(20,20),NWY(20,20),NEXX(20,20),NEXY(20,20),NINX(2
         10,20),NINY(20,20),ILOCWO(100),JLOCWO(100),NSR(100),NWOLD(100),NW,N
         2W1,NW2,NWO,NWO1,NWO2,FAILO
C FORM SHIFTED MATRICES: NYU=NY SHIFTED ONE ROW UP,   NXR=NX SHIFTED ONE
C COLUMN TO RIGHT $
          LOGICAL LE,LX,LY,FAILO
          DIMENSION NXR(20,20),NYU(20,20),IX(20,20),IY(20,20)
          NGY1=NGY-1
          NGX1=NGX-1
C IF THIS IS A REORGANIZATION, HOLD OLD WALL NOS FOR LATER TRANSFER TO NWOLD $
          IF(.NOT.FAILO)GO TO 50
          DO 51 I=1,NGY
          DO 51 J=1,NGX
          IX(I,J)=NWX(I,J)
       51 IY(I,J)=NWY(I,J)
       50 CONTINUE
          L=0
        1 DO 10 J=1,NGX1
          J1=J+1
          DO 10 I=1,NGY
          NXR(I,J1)=NX(I,J)
          KIND(I,J1)=L
          NWX(I,J1)=0
          NWY(I,J1)=0
       10 CONTINUE
          DO 11 I=1,NGY
          KIND(I,1)=L
          NWX(I,1)=0
          NWY(I,1)=0
C LAST COLUMN OF NX(I,J) CONTAINS ALL ZEROES $
          NXR(I,1)=0
       11 CONTINUE
          DO 15 I=1,NGY1
          I1=I+1
          DO 15 J=1,NGX
       15 NYU(I1,J)=NY(I,J)
C LAST ROW OF NY CONTAINS ALL ZEROES
          DO 16 J=1,NGX
       16 NYU(1,J)=0
C FIND FOUR-WAY CORNERS 4RNSEW $
C REMOVE HANGING WALLS $
          DO 20 I=1,NGY
          DO 20 J=1,NGX
          N=NX(I,J)+NXR(I,J)+NY(I,J)+NYU(I,J)
          IF(N.EQ.4)KIND(I,J)=1111
          IF(N.NE.1)GO TO 20
C IF N.EQ.1 WALL MUST END AT GRID POINT (I,J) WITHOUT FORMING A CORNER
C THERE $ FIND ORIGIN OF WALL AND REMOVE IT $
          WRITE(6,901)I,J
          J1=J-1
          IF(J1.EQ.0)GO TO 23
          IF(NX(I,J1).NE.1)GO TO 23
```

```
      NX(I,J1)=0
C IF WALL IS REMOVED, START SUBROUTINE CORNER OVER AGAIN $
      GO TO 1
   23 IF(NX(I,J).NE.1)GO TO 24
      NX(I,J)=0
      GO TO 1
   24 I1=I-1
      IF(I1.EQ.0)GO TO 25
      IF(NY(I1,J).NE.1)GO TO 25
      NY(I1,J)=0
      GO TO 1
   25 IF(NY(I,J).NE.1)GO TO 29
      NY(I,J)=0
      GO TO 1
   29 WRITE(6,900)I,J
  900 FORMAT(/18H SUBROUTINE CORNER/5X,10HERROR EXIT/5X,30HCANT FIND HAN
     1GING WALL AT I,J=,2I6//)
      CALL EXIT
   20 CONTINUE
  901 FORMAT(/18H SUBROUTINE CORNER/5X,25HHANGING WALL ENDS AT I,J=,2I6)
C FIND THREE-WAY CORNERS: 4RN EW,4R SEW,4RNS W,4RNSE  $
      DO 30 I=1,NGY
      DO 30 J=1,NGX
      IF(KIND(I,J).NE.L)GO TO 30
      N1=NX(I,J)+NXR(I,J)
      N2=NY(I,J)+NYU(I,J)
      N3=N1+NY(I,J)
      IF(N3.NE.3)GO TO 31
      KIND(I,J)=1011
      GO TO 30
   31 N3=N1+NYU(I,J)
      IF(N3.NE.3)GO TO 32
      KIND(I,J)=0111
      GO TO 30
   32 N3=N2+NX(I,J)
      IF(N3.NE.3)GO TO 33
      KIND(I,J)=1110
      GO TO 30
   33 N3=N2+NXR(I,J)
      IF(N3.NE.3)GO TO 30
      KIND(I,J)=1101
   30 CONTINUE
C FIND TWO-WAY CORNERS: 4RN E ,4RN  W,4R SE ,4R S W $
C TREAT PILASTERS AS FORMING 4RNS  ,4R  EW CORNERS $
      DO 40 I=1,NGY
      DO 40 J=1,NGX
      IF(KIND(I,J).NE.L)GO TO 40
      N1=NX(I,J)
      N2=NXR(I,J)
      N3=NY(I,J)
      N4=NYU(I,J)
      N5=0
      IF(PLSTR(I,J).GT.0.)N5=1
      IF((N1+N3).NE.2)GO TO 41
      KIND(I,J)=1010
      GO TO 40
   41 IF((N1+N4).NE.2)GO TO 42
      KIND(I,J)=0110
      GO TO 40
   42 IF((N2+N3).NE.2)GO TO 43
      KIND(I,J)=1001
      GO TO 40
   43 IF((N2+N4).NE.2)GO TO 44
      KIND(I,J)=0101
      GO TO 40
   44 IF((N1+N2+N5).NE.3)GO TO 45
      KIND(I,J)=0011
      GO TO 40
   45 IF((N3+N4+N5).NE.3)GO TO 40
      KIND(I,J)=1100
   40 CONTINUE
C NUMBER WALLS AND STORE E-W WALLS WITH GRID POINT IN NWX(I,J)
C AND N-S WALLS IN NWY(I,J) $
C E-W WALL NOS. EVEN, N-S WALLS ODD $
      NW=0
      NW1=0
      NW2=0
```

```
C NW=TOTAL NO. OF WALLS=NW1+NW2, SUM OF E-W AND N-S WALLS $
C LE=.TRUE. MEANS THERE IS A WALL COMING INTO GRID POINT (I,J) $
      DO 60 I=1,NGY
      LE=.FALSE.
      DO 60 J=1,NGX
      K=KIND(I,J)
      IF((K.EQ.L).AND.(.NOT.LE))GO TO 60
      IF(K.NE.L)GO TO 61
      K1=K1+1
      GO TO 60
   61 IF(LE)GO TO 62
C
C
      IF(NX(I,J).NE.0)LE=.TRUE.
      K1=0
      GO TO 60
   62 K1=K1+1
      NW=NW+2
      NW1=NW1+1
C STORE WALL NO. UNDER ALL ITS SEGMENTS $
      II=J-K1
      J1=J-1
      DO 70 IJ=II,J1
   70 NWX(I,IJ)=NW
      K1=0
      IF(FAILO)NWOLD(NW)=IX(I,II)
      IF(NX(I,J).EQ.0)LE=.FALSE.
   60 CONTINUE
C BEGIN FILLING OF NWY(I,J) WITH ODD-NUMBERED N-S WALLS $
      NW=-1
      DO 80 J=1,NGX
      LE=.FALSE.
      DO 80 I=1,NGY
      K=KIND(I,J)
      IF((K.EQ.L).AND.(.NOT.LE))GO TO 80
      IF(K.NE.L)GO TO 81
      K1=K1+1
      GO TO 80
   81 IF(LE)GO TO 82
      IF(NY(I,J).NE.0)LE=.TRUE.
      K1=0
      GO TO 80
   82 K1=K1+1
      NW=NW+2
      NW2=NW2+1
      II=I-K1
      I1=I-1
      DO 90 IJ=II,I1
   90 NWY(IJ,J)=NW
      K1=0
      IF(FAILO)NWOLD(NW)=IY(II,J)
      IF(NY(I,J).EQ.0)LE=.FALSE.
   80 CONTINUE
      NW=NW1+NW2
C WRITE RESULTS OF CORNER $
      WRITE(6,902)
  902 FORMAT(/18H SUBROUTINE CORNER//22X,16HKINDS OF CORNERS//)
      DO 85 I=1,NGY
      WRITE(6,903)(KIND(I,J),J=1,NGX)
  903 FORMAT(/5X,12(I4,1X))
   85 CONTINUE
      WRITE(6,904)
  904 FORMAT(//22X,16HE-W WALL NUMBERS//)
      DO 95 I=1,NGY
   95 WRITE(6,905)(NWX(I,J),J=1,NGX)
  905 FORMAT(5X,12(I4,1X))
      WRITE(6,906)
  906 FORMAT(//22X,16HN-S WALL NUMBERS//)
      DO 96 I=1,NGY
   96 WRITE(6,905)(NWY(I,J),J=1,NGX)
      WRITE(6,907)NW1,NW2,NW
C WRITE OLD AND NEW WALL NOS AFTER REORG $
      IF(.NOT.FAILO)GO TO 52
      WRITE(6,908)
  908 FORMAT(18H SUBROUTINE CORNER/5X,41HNEW AND OLD WALL NOS AFTER REOR
     1GANIZATION//10X,3HNEW,5X,3HOLD/)
      IF(NW1.EQ.0)GO TO 57
```

```
      DO 53 I=1,NW1
      II=2*I
   53 WRITE(6,909)II,NWOLD(II)
   57 IF(NW2.EQ.0)GO TO 52
      DO 54 I=1,NW2
      II=2*I-1
   54 WRITE(6,909)II,NWOLD(II)
  909 FORMAT(5X,2I8)
   52 CONTINUE
C END CORNER $
      RETURN
  907 FORMAT(//5X,17HNO. OF E-W WALLS=,I5/5X,17HNO. OF N-S WALLS=,I5//16
     1X,6HTOTAL=,I5/)
C END SUBROUTINE CORNER
      END
C
C
      SUBROUTINE OUTER(AREA)
C CREATES INTERSECTION MATRICES OF OUTER WALLS, NXO(I,J) & NYO(I,J)
C AND NEXX(I,J) & NEXY(I,J) $
C FINDS AREA WITHIN OUTER WALLS $
C RETRIEVES WALL SEQ. NOS FROM NWX & NWY AND ENTERS IN NEXX & NEXY $
C FILLS  LOCATOR VECTORS ILOCWO,JLOCWO(NO.WALL) FOR OUTER WALLS WITH
C REGULAR SEQUENCE NOS $
C CREATES SPECIAL SEQ. NOS FOR OUTER WALLS AND ENTERS IN NXO,NYO $
C NSR(SPECIAL NO.)=REG. NO.
      COMMON /GRID/ DUM(8800),DIMX(20),DIMY(20),NXO(20,20),NYO(20,20),NG
     1X,NGY
      COMMON /CRNR/ KIND(20,20),NE(20,20)
      COMMON /WAND/ NWX(20,20),NWY(20,20),NEXX(20,20),NEXY(20,20),NINX(2
     10,20),NINY(20,20),ILOCWO(100),JLOCWO(100),NSR(100),NWOLD(100),NW,N
     2W1,NW2,NWO,NWO1,NWO2,FAILO
      LOGICAL LE
      LOGICAL LNORTH,LSOUTH,LEAST,LWEST
      LNORTH(I)=(I.EQ.1000).OR.(I.EQ.1100).OR.(I.EQ.1010).OR.(I.EQ.1001
     1).OR.(I.EQ.1110).OR.(I.EQ.1011).OR.(I.EQ.1101).OR.(I.EQ.1111)
      LSOUTH(I)=(I.EQ.0100).OR.(I.EQ.1100).OR.(I.EQ.0110).OR.(I.EQ.0101
     1).OR.(I.EQ.1110).OR.(I.EQ.0111).OR.(I.EQ.1101).OR.(I.EQ.1111)
      LEAST(I)=(I.EQ.0010).OR.(I.EQ.1010).OR.(I.EQ.0110).OR.(I.EQ.0011)
     1.OR.(I.EQ.1110).OR.(I.EQ.0111).OR.(I.EQ.1011).OR.(I.EQ.1111)
      LWEST(I)=(I.EQ.0001).OR.(I.EQ.1001).OR.(I.EQ.0101).OR.(I.EQ.0011)
     1.OR.(I.EQ.1101).OR.(I.EQ.0111).OR.(I.EQ.1011).OR.(I.EQ.1111)
      NWO=0
      NWO1=0
      NO=0
      NWO2=0
      L=0
      DO 10 I=1,NGY
      DO 10 J=1,NGX
      NXO(I,J)=0
      NYO(I,J)=0
      NEXX(I,J)=0
      NEXY(I,J)=0
   10 CONTINUE
      DO 11 I=1,NW
      ILOCWO(I)=0
   11 JLOCWO(I)=0
C FIND MOST SOUTHERLY THEN MOST WESTERLY NE CORNER $
      DO 15 I=1,NGY
      IO=I
      DO 15 J=1,NGX
      JO=J
      IF(NE(I,J).NE.0)GO TO 20
   15 CONTINUE
      WRITE(6,900)
      WRITE(6,912)
  912 FORMAT(/5X,18HMATRIX NE IS EMPTY/)
      CALL EXIT
C MAKE SURE NE CORNER IS AN OUTSIDE CORNER $
C NWO2=NO. E-W OUTSIDE WALLS $
C NWO1=NO. N-S OUTSIDE WALLS $
   20 I=IO
C NWO=TOTAL NO. OF OUTSIDE WALLS $
      J=JO
      IF(KIND(I,J).NE.1010)GO TO 100
C GO NORTH $ VARIABLE ITRY RECORDS NO.OF ATTEMPTS TO FIND CONTIGUOUS WALL $
C ASSIGN SEQ. NO. TO EVERY SEGMENT OF N-S WALL $ FILL INTERSECTION MATRIX $
```

```
C ONLY ORIGIN OF WALL STORED IN LOCATOR VECTORS ILOCWO & JLOCWO
C ORIGIN OF WALL IS ITS MOST SW END
   21 ITRY=0
      N=NWY(I,J)
      IF(N.EQ.0)GO TO 130
      JLOCWO(N)=J
      ILOCWO(N)=I
      NEXY(I,J)=N
      IF(N.EQ.N0)GO TO 30
      NW01=NW01+1
      N0=N
   30 CONTINUE
      NYO(I,J)=1
      I=I+1
C IF THERE IS NO CORNER, CONTINUE NORTH $ CHECK FOR OVERRUNNING GRID $
      IF(I.GT.NGY)GO TO 70
      IF(KIND(I,J).EQ.L)GO TO 21
C IF THERE IS A CORNER, TRY TO GO WEST $ IF NOT TRY NORTH $
   22 ITRY=ITRY+1
      IF(ITRY.GT.3)GO TO 60
      K=KIND(I,J)
      IF(.NOT.LWEST(K))GO TO 24
C GO WEST $
   23 ITRY=0
      J=J-1
      IF(J.LT.1)GO TO 70
      N=NWX(I,J)
      IF(N.EQ.0)GO TO 130
      IF(N.EQ.N0)GO TO 31
      NW02=NW02+1
      ILOCWO(N)=I
      N0=N
   31 CONTINUE
      NEXX(I,J)=N
      NXO(I,J)=1
      JLOCWO(N)=J
C CHECK FOR RETURN TO STARTING POINT $
      IF((I.EQ.I0).AND.(J.EQ.J0))GO TO 80
C IF THERE IS NO CORNER, CONTINUE WEST $
      IF(KIND(I,J).EQ.L)GO TO 23
C IF THERE IS A CORNER, TRY SOUTH $ IF NOT SOUTH, TRY WEST $
   25 ITRY=ITRY+1
      IF(ITRY.GT.3)GO TO 60
      K=KIND(I,J)
      IF(.NOT.LSOUTH(K))GO TO 22
C GO SOUTH $
   26 ITRY=0
      I=I-1
      IF(I.LT.1)GO TO 70
      N=NWY(I,J)
      IF(N.EQ.0)GO TO 130
      IF(N.EQ.N0)GO TO 32
      NW01=NW01+1
      N0=N
      JLOCWO(N)=J
   32 CONTINUE
      NEXY(I,J)=N
      ILOCWO(N)=I
      NYO(I,J)=1
C IF THERE IS NO CORNER, CONTINUE SOUTH $
      IF(KIND(I,J).EQ.L)GO TO 26
C IF THERE IS A CORNER, TRY EAST $ IF NOT EAST, TRY SOUTH $
      GO TO 28
C GO EAST $
   27 ITRY=0
      N=NWX(I,J)
      IF(N.EQ.0)GO TO 130
      NEXX(I,J)=N
      IF(N.EQ.N0)GO TO 33
      JLOCWO(N)=J
      ILOCWO(N)=I
      NW02=NW02+1
      N0=N
   33 CONTINUE
      NXO(I,J)=1
      J=J+1
```

```
      IF(J.GT.NGX)GO TO 70
C IF THERE IS NO CORNER, CONTINUE EAST $
      IF(KIND(I,J).EQ.L)GO TO 27
C IF THERE IS A CORNER, TRY NORTH $ IF NOT NORTH, TRY EAST $
   24 ITRY=ITRY+1
      IF(ITRY.GT.3)GO TO 60
      K=KIND(I,J)
      IF(LNORTH(K))GO TO 21
C TRY EAST $ IF NOT EAST, TRY SOUTH $
   28 ITRY=ITRY+1
      IF(ITRY.GT.3)GO TO 60
      K=KIND(I,J)
      IF(.NOT.LEAST(K))GO TO 25
      GO TO 27
   60 WRITE(6,900)
  900 FORMAT(/17H SUBROUTINE OUTER/5X,10HERROR EXIT/)
      WRITE(6,901)I,J,KIND(I,J)
  901 FORMAT(/5X,41HTOO MANY TRIES TO FIND OUTER WALL AT I,J=,2I6/5X,10H
     1KIND(I,J)=,1X,I4/)
      CALL EXIT
   70 WRITE(6,900)
      WRITE(6,902)I,J,NGX,NGY
  902 FORMAT(/5X,20HOVERRAN GRID AT I,J=,2I6/5X,8HNGX,NGY=,2I6/)
      CALL EXIT
  100 WRITE(6,900)
      WRITE(6,903)I,J,KIND(I,J)
  903 FORMAT(/5X,36HCANT FIND NE CORNER TO START AT I,J=,2I6/5X,10HKIND(
     1I,J)=,1X,I4/)
      CALL EXIT
   80 NWO=NWO1+NWO2
C FIND AREA OF FLOOR FROM NYO $
      AREA=0.
      LE=.FALSE.
      NGY1=NGY-1
      DO 50 I=1,NGY1
      IF(LE)GO TO 110
      DO 50 J=1,NGX
      IF(NYO(I,J).NE.0)GO TO 51
      IF(.NOT.LE)GO TO 50
   53 AREA=AREA+DIMX(J)*DIMY(I)
      GO TO 50
   51 IF(LE)GO TO 52
      LE=.TRUE.
      GO TO 53
   52 LE=.FALSE.
   50 CONTINUE
C FIND AREA OF FLOOR FROM NXO $
      A=0.
      NGX1=NGX-1
      DO 55 J=1,NGX1
      IF(LE)GO TO 110
      DO 55 I=1,NGY
      IF(NXO(I,J).NE.0)GO TO 56
      IF(.NOT.LE)GO TO 55
   58 A=A+DIMX(J)*DIMY(I)
      GO TO 55
   56 IF(LE)GO TO 57
      LE=.TRUE.
      GO TO 58
   57 LE=.FALSE.
   55 CONTINUE
      IF(LE)GO TO 110
      IF(ABS(A-AREA).GT.1.E-50)GO TO 120
C PRINT RESULTS OF SUBROUTINE OUTER $
      WRITE(6,905)AREA,NWO1,NWO2
  905 FORMAT(/17H SUBROUTINE OUTER//5X,17HTOTAL FLOOR AREA=,E12.4,11H  S
     1Q METERS/5X,17HNO. OF N-S WALLS=,I5/5X,17HNO. OF E-W WALLS=,I5/)
      WRITE(6,906)
  906 FORMAT(//5X,43HOUTSIDE INTERSECTION MATRICES WITH WALL NOS//10X,
     14HNEXX)
      DO 90 I=1,NGY
   90 WRITE(6,907)(NEXX(I,J),J=1,NGX)
  907 FORMAT(/10X,15I5)
      N2=0
      NO=0
      WRITE(6,908)
  908 FORMAT(//10X,4HNEXY)
```

```
      DO 91 I=1,NGY
   91 WRITE(6,907)(NEXY(I,J),J=1,NGX)
C ASSIGN SPECIAL SEQ. NOS TO OUTSIDE WALLS IN ORDER TO REDUCE SPACE
C REQUIRED FOR PRESSURE-TIME DATA $
C SPECIAL NOS STORED IN NXO,NYO $ NSR(SPEC.NO.)=REG.NO. $
C SPECIAL OUTSIDE WALL NOS ARE EVEN FOR E-W WALLS, ODD FOR N-S $
C NOTE THAT THERE MAY BE MORE OF ONE THAN THE OTHER $
      IUP=MAX0(NWO1,NWO2)
      IUP=2*IUP
      DO 37 I=1,IUP
   37 NSR(I)=0
      N1=-1
      DO 75 I=1,NGY
      DO 75 J=1,NGX
      IF(NXO(I,J).EQ.0)GO TO 75
      N=NEXX(I,J)
      IF(N.EQ.NO)GO TO 35
      N2=N2+2
      NO=N
      NSR(N2)=N
   35 CONTINUE
      NXO(I,J)=N2
   75 CONTINUE
      DO 76 J=1,NGX
      DO 76 I=1,NGY
      IF(NYO(I,J).EQ.0)GO TO 76
      N=NEXY(I,J)
      IF(N.EQ.NO)GO TO 36
      N1=N1+2
      NO=N
      NSR(N1)=N
   36 CONTINUE
      NYO(I,J)=N1
   76 CONTINUE
C CHECK ON TOTALS $
      N4=N2/2
      N3=(N1+1)/2
      IF(NWO1.EQ.N3)GO TO 140
      WRITE(6,900)
      WRITE(6,915)NWO1,N1
  915 FORMAT(/5X,32HNO. N-S WALLS IN NYO NOT CORRECT/5X, 8HNWO1,N1=,2I4)
      CALL EXIT
  140 IF(NWO2.EQ.N4)RETURN
      WRITE(6,900)
      WRITE(6,916)NWO2,N2
  916 FORMAT(/5X,32HNO. E-W WALLS IN NXO NOT CORRECT/5X,8HNWO2,N2=,2I4)
      CALL EXIT
  120 WRITE(6,900)
      WRITE(6,910)AREA,A
  910 FORMAT(/5X,18HFLOOR AREAS DIFFER/5X,14HAREA FROM NYO=,E12.4/10X,9H
     1FROM NXO=,E12.4/)
      CALL EXIT
  110 WRITE(6,900)
      WRITE(6,911)I,J,IO,JO
  911 FORMAT(/5X,22HUNPAIRED WALLS AT I,J=,2I5/5X,15HSTART AT IO,JO=,2I5
     1)
      CALL EXIT
  130 WRITE(6,900)
      WRITE(6,913)I,J
  913 FORMAT(/5X,28HNO WALL WHERE KIND SHOWS ONE/5X,4HI,J=,2I5/)
      CALL EXIT
      RETURN
C END SUBROUTINE OUTER
      END
C
C
      SUBROUTINE POUT(N,P,T)
C SUBROUTINE POUT COMPUTES EXTERNAL PRESSURE HISTORY P VS T FOR OUTSIDE
C WALL NO. N (REG. SERIES) $ P(I) IS PRESSURE(PASCALS) AT TIME T(I)(SEC) $
C TIME T RELATIVE TO ARRIVAL AT WALL $
      COMMON /BLAST/ PSO,TO,PO,ALPH,TEMP,DELT,RHOO,PR,CDF,CDR,CDS,QO,ALP
     1HA,BETA,A,B,TC(50),U
C CDF,CDR,CDS ARE DRAG COEFFS FOR FRONT, REAR AND SIDE WALLS $
C IF N IS EVEN, INCIDENCE IS HEAD-ON OR REAR-ON $
      COMMON /GRID/ NDUM(8800),XDUM(40),NXO(20,20)
      COMMON /WAND/ NWX(20,20),NWY(20,20),NEXX(20,20),NEXY(20,20),NINX(2
     10,20),NINY(20,20),ILOCWO(100),JLOCWO(100),NSR(100),NWOLD(100),NW,N
```

```
      2W1,NW2,NWO,NWO1,NWO2,FAILO
       COMMON /PROP/ NDU1(20),DUM(100),SPAN(20)
       COMMON /RESP/ DEFL(20),VEL(20),ACCEL(20)
       DIMENSION P(50),T(50)
       PS(TAU)=PSO*(1.-TAU)*(A*EXP(-ALPHA*TAU)+B*EXP(-BETA*TAU))+C*QO*(1.
      1-TAU)*(1.-TAU)*EXP(-2.*TAU)
       DO 20 I=1,50
       P(I)=0.
    20 T(I)=0.
       T(1)=0.
C DETERMINE IF INCIDENCE IS HEAD-ON OR REAR-ON $
       IF(MOD(N,2))1,3,1
     3 K=0
       I=ILOCWO(N)
       J=JLOCWO(N)
       DO 5 II=1,I
       IF(NXO(II,J).EQ.0)GO TO 5
       K=K+1
     5 CONTINUE
       IF(MOD(K,2))2,4,2
C COMPUTE PRESSURE HISTORY FOR REAR-FACING AND FORWARD-FACING WALLS $
     4 P(1)=0.
       C=CDR
       P1=0.
       GO TO 6
     2 P(1)=PR
       C=CDF
       P1=PR
     6 T1=1.3*TC(N)/TO
       P2=PS(T1)
       T2=0.
       DO 7 I=2,50
       T2=T2+DELT
       T(I)=T2
       IF(T2.GT.T1)GO TO 8
       P(I)=P1+(P2-P1)*T2/T1
       GO TO 7
     8 TAU=T2/TO
       P(I)=PS(TAU)
     7 CONTINUE
       GO TO 10
C FIND PRESSURE HISTORY FOR SIDEWALL $
     1 P(1)=0.
       C=CDS
C LENGTH OF SIDEWALL IS YFAC $
       YFAC=SPAN(N)
       T1=YFAC/U
C WAVE TIME IS AN AVERAGE OF TIMES AT TWO ENDS OF WALL $
       T2=0.
       T3=T1/(2.*TO)
       P2=PS(T3)
       DO 9 I=2,50
       T2=T2+DELT
       T(I)=T2
       IF(T2.GT.T1)GO TO 15
       TAU=T2/TO
       P2=(PS(TAU)+PSO)/2.
       P(I)=P2*T2/T1
       GO TO 9
    15 TAU=T2/TO-T3
       P(I)=PS(TAU)
     9 CONTINUE
    10 WRITE(6,901)N
   901 FORMAT(/16H SUBROUTINE POUT/5X,9HWALL NO.=,I5/22X,11H  TIME(SEC),5
     1X,16HPRESSURE(PASCAL)/)
       WRITE(6,902)(T(I),P(I),I=1,50)
   902 FORMAT(21X,E12.4,6X,E12.4)
   701 CONTINUE
       RETURN
C END SUBROUTINE POUT
       END
C
C
       SUBROUTINE FLOW(P3,P1,RHO3,A,V,M,W,OUT)
C INPUT:
C
C   P3=ROOM PRESSURE (PASCAL)
```

```
C    P1=PRESSURE OUTSIDE OPENING (PASCAL)
C    RHO3=AIR DENSITY IN ROOM (KG/CUBIC METER)
C    A=AREA OF OPENING (SQUARE METERS)
C    V=VOLUME OF ROOM (CUBIC METERS)
C OUTPUT:
C
C    M=MASS FLOW (KG) DURING TIME INCREMENT DELT
C    W=ENERGY INCREMENT (JOULE) DURING DELT
C    OUT=LOGICAL,OUTFLOW OR INFLOW
C
C ASSUME RATIO OF SPECIFIC HEATS=1.4
C
      COMMON /BLAST/ PSO,TO,PO,ALPH,TEMP,DELT,RHO0
      COMMON /SPHT/ G,G1,G2,G3,G4,G5,G6,G7,G0,CR,K
      REAL K,M
      LOGICAL OUT
C CALC OUTSIDE DENSITY (APPROX) FROM ISENTROPIC EQ OF STATE $
C CR=CRITICAL PRESSURE RATIO FOR DETERMINING CHOKED FLOW $
      IF(P3.GT.P1)GO TO 30
      RHO1=RHO0*(P1/PO)**G1
      OUT=.FALSE.
      P31=P3/P1
      IF(P31.LT.CR)GO TO 10
      M=K*RHO1*SQRT(G5*P1*(1.-P31**G6)/RHO1)*P31**G1*A*DELT
      GO TO 20
   10 M=K*SQRT(RHO1*P1*G4)*A*DELT
   20 W=G2*P1*M/RHO1
      RETURN
   30 M=0.
      W=0.
      OUT=.TRUE.
      RETURN
C END SUBROUTINE FLOW $
      END
C
C
C
      SUBROUTINE WALL(N,P1,P3,F,OUT)
C N=WALL NO.
C P1=OUTSIDE PRESSURE (KPA)
C P3=INSIDE PRESSURE (KPA)
C F=LOGICAL, FAIL OR NOT FAIL
C OUT=LOGICAL,WALL DEFL INWARD OR OUTWARD $
C CRACK IS TRUE AFTER WALL CRACKS AT EDGES $
C REVERS IS TRUE AFTER FIRST CHANGE IN DIRECTION OF WALL MOTION $
      COMMON /TYM/ TIME
      COMMON /BLAST/ PSO,TO,PO,ALPH,TEMP,DELT
      COMMON /PROP/ ICASE(20),FR(20),PV(20),FCP(20),EM(20),GAMMA(20
     1),SPAN(20),HGHT,TW(20)
      COMMON /RESP/ DEFL(20),VEL(20),ACCEL(20),FIRST(20)
      COMMON /PROP1/ MASS(20),AWALL(20)
      COMMON /PROP2/ KF0(20),KS0(20)
      COMMON /PROP3/ KLMSE(20),KLMFE(20),KLM(20),KLMP(20),VH1S0(20),VH2S
     10(20),VV1P0(20),VV2P0(20),VV2F0(20),KEP0(20),KEQ0(20),VH1P0(20),
     2VV1S0(20),VV2S0(20),VH1F0(20),VH2F0(20),VV1F0(20),VH2P0(20)
      COMMON /PROP4/ QU0(20),YU0(20),Y10(20),Q10(20),Q20(20),YFAIL0(20)
     1,Y20(20),CRACK(20),Y40(20),REVERS(20)
      COMMON /WNDW/ ZLHW(20),ZLVW(20),AWIN(20)
      COMMON /SHEAR/ VH10(20),VH20(20),VV10(20),VV20(20),VFAIL0(20)
      LOGICAL OUT,F,FIRST,REVERS,CRACK
      REAL MASS,KLM,KF0,KS0,KLMSE,KLMFE,KLMP,KEP0,KEQ0
      F=.FALSE.
      OUT=.FALSE.
      AREA=AWALL(N)
      PEXT=P1
      DELTA=DELT
      PINT=P3
      R=PEXT/PINT-1
      IF(R.GT.1.E-10)GO TO 5
      TPNET=0.
      GO TO 6
    5 TPNET=AREA*(PEXT-PINT)
    6 ZKLM=KLM(N)
      Y0=DEFL(N)
      A0=ACCEL(N)
      ZMASS=MASS(N)
      IF(.NOT.FIRST(N))GO TO 10
```

```
      AO=TPNET/(ZMASS*ZKLM)
      FIRST(N)=.FALSE.
   10 CONTINUE
      VFAIL=VFAILO(N)
      YFAIL=YFAILO(N)
      VO=VEL(N)
      A=AO
      DO 8 JJ=1,10
      Y=YO+DELTA*VO+DELTA*DELTA*(AO/3.+A/6.)
      CALL RESIST(N,Y,Q,2)
      QT=Q*AREA
      ANEW=(TPNET-QT)/(ZMASS*ZKLM)
      ADELTA=ANEW-A
      A=ANEW
      IF(ANEW.EQ.0.)WRITE(6,901)TIME,TPNET,QT,ZMASS,ZKLM,Y,AO
  901 FORMAT(/16H SUBROUTINE WALL/5X,4H1985,2X,14HTIME,TPNET,QT=,
     13E12.4/5X,11HZMASS,ZKLM=,2E12.4/5X,5HY,AO=,2E12.4/)
      IF(ABS(ADELTA/(ANEW+1.E-10)).LT.0.01)GO TO 9
    8 CONTINUE
      A=ANEW-ADELTA/2.
      WRITE(6,80)N,TIME,A,Y
   80 FORMAT(/16H SUBROUTINE WALL/5X,9HWALL NO.=,I6/5X,37HACCELERATION NOT
     1OT  CONVERGING AT TIME=,F6.3,5H SEC /5X,14HA SET EQUAL TO,
     2F8.1,29H (AVG OF LAST TWO ITERATIONS)/5X,3HY =,
     3F8.4,6H METER)
    9 CONTINUE
      Y=YO+DELTA*VO+DELTA*DELTA*(AO/3.+A/6.)
      V=VO+DELTA*(A+AO)/2.
      VH1=VH1O(N)
      VH2=VH2O(N)
      VV1=VV1O(N)
      VV2=VV2O(N)
      VV=VV1*TPNET+VV2*QT
      VH=VH1*TPNET+VH2*QT
      IF(VV.GT.VFAIL)GO TO 7
      OUT=.FALSE.
      IF(ABS(Y).GE.YFAIL)F=.TRUE.
      IF(Y.LT.0.)OUT=.TRUE.
C FIRST TIME DIRECTION OF MOTION REVERSES SET REVERS(N)=.T. $
      IF(ABS(Y).LT.ABS(YO))REVERS(N)=.TRUE.
      DEFL(N)=Y
      VEL(N)=V
      ACCEL(N)=A
      RETURN
    7 WRITE(6,900)N,TIME
  900 FORMAT(/16H SUBROUTINE WALL/5X,13HSHEAR FAILURE/5X,9HWALL NO.=,
     1I6,2X,8HAT TIME=,E11.4,2X,5H(SEC)/)
      CALL EXIT
C END SUBROUTINE WALL
      END
C
C
C
      SUBROUTINE RESIST (N,Y,Q,IENTRY)
C
C:  THIS SUBROUTINE DETERMINES THE RESISTANCE FUNCTION FOR AN
C:  UNREINFORCED MASONRY WALL WITH OR WITHOUT OPENINGS.  CASES
C:  1-4 ARE TWO-WAY WALLS AND CASES 5-7 ARE ONE-WAY WALLS
C N=WALL NO.(REG.) $ Y=CURRENT DEFLECTION $ Q=VALUE OF RESISTANCE RETURNED $
C IENTRY=1 USED FOR INITIALIZATION, IENTRY=2 COMPUTES RESISTANCE $
C
      COMMON /PROP/ ICS(20),FRO(20),PVO(20),FCP(20),EM(20),GAMMO(20
     1),SPAN(20),HGHT,TH(20)
      COMMON /RESP/ DEFL(20),VEL(20),ACCEL(20)
      COMMON /PROP1/ MASS(20),AWALLO(20)
      COMMON /PROP2/ KFO(20),KSO(20)
      COMMON /PROP3/ KLMSE(20),KLMFE(20),KLM(20),KLMP(20),VH1SO(20),VH2S
     1O(20),VV1PO(20),VV2PO(20),VV2FO(20),KEPO(20),KEQO(20),VH1PO(20),
     2VV1SO(20),VV2SO(20),VH1FO(20),VH2FO(20),VV1FO(20),VH2PO(20)
      COMMON /PROP4/ QUO(20),YUO(20),Y1O(20),Q1O(20),Q2O(20),YFAILO(20)
     1,Y2O(20),CRACK(20),Y4O(20),REVERS(20)
      COMMON /WNDW/ ZLHWO(20),ZLVWO(20),AWINO(20)
      COMMON /SHEAR/ VH1O(20),VH2O(20),VV1O(20),VV2O(20),VFAIL(20)
      LOGICAL CRACK,REVERS,HYSTER
      REAL K1,K2,K3,KUD,IC,ICTOT,IG,KK1,KK2,KK3,MM,MPR,MPRSQ
      REAL KS,KF,KEP,KEQ,NU,MU
      REAL KEPO,KEQO,MASS,KLMSE,KLMFE,KLM,KLMP,KSO,KFO
```

```
C
      GOTO(5,500),IENTRY
C
C FETCH PARAMETERS FROM COMMON $
    5 CONTINUE
C CDC MACHINES INITIALIZE TO ZERO $
C FOR ICASE=1 Q1,KF AND KEP MUST BE SET EQUAL TO ZERO $
C
      Q1=0.
      KF=0.
      KEP=0.
      ZLH=SPAN(N)
      ZLV=HGHT
      ZLHW=ZLHW0(N)
      ZLVW=ZLVW0(N)
      AWIN=AWIN0(N)
      ICASE=ICS(N)
      AREA=AWALL0(N)
      AWALL=AREA+AWIN
      ZMASS=MASS(N)
      TW=TH(N)
      PV=PV0(N)
      E=EM(N)
      FR=FR0(N)
      GAMMA=GAMM0(N)
C
C:   DETERMINE ELASTIC DEFLECTION AND MOMENT COEFFICIENTS FOR
C:   TWO-WAY WALLS WITHOUT INPLANE FORCES
      R=ZLH/ZLV
      ALP=1.0/R
      ALP2=ALP*ALP
      IF(ICASE.LE.4)GOTO 11
      R=0
      ALP=0
      ALP2=0
   11 CONTINUE
      B=0.5*(ALP*SQRT(3.0+ALP2)-ALP2)
      IG=TW**3/12.0
      CALL COEF (ICASE,R,ASS,BSS,AF,BF,IG,ZLV,ZLH,PV,NX,CF,E,1)
      CALL TRANS (B,ZLV,ZLH,ICASE,0,ZKLM,ZKLMSE,ZKLMFE,ZKLMP,VH1S,
     1VH2S,VV1S,VV2S,VH1F,VH2F,VV1F,VV2F,VH1P,VH2P,VV1P,VV2P)
      KLMSE(N)=ZKLMSE
      KLM(N)=ZKLM
      KLMFE(N)=ZKLMFE
      KLMP(N)=ZKLMP
      VH1S0(N)=VH1S
      VH2S0(N)=VH2S
      VH1F0(N)=VH1F
      VH2F0(N)=VH2F
      VV1S0(N)=VV1S
      VV2S0(N)=VV2S
      VV1F0(N)=VV1F
      VV2F0(N)=VV2F
      VH1P0(N)=VH1P
      VH2P0(N)=VH2P
      VV1P0(N)=VV1P
      VV2P0(N)=VV2P
      VFAIL(N)=1.E+10
C
C:   DETERMINE MODIFICATION FACTOR FOR WALL WITH WINDOWS
C
  290 QMULT=1.0
      IF(AWIN.NE.0)CALL WINDOW (QMULT,ZLV,ZLH,ZLVW,ZLHW,AWIN,AWALL,
     1R,ICASE)
C
C:   DETERMINE MAXIMUM RESISTANCE DURING DECAYING PHASE
C
      MM=(FR+PV/TW)*TW*TW/6.0
      W=ZLV*TW*GAMMA*9.80
      IF(ICASE.GT.4)GOTO 278
      QEZERO=12.0*TW*(2.0*PV+W)*(1.0+0.5*ALP2/B)/(ZLV*ZLV*(3-2*B))
      GOTO 279
  278 QEZERO=8.0*TW*(PV+0.25*W)/(ZLV*ZLV)
  279 CONTINUE
      YFAIL=TW
      KEQ=QEZERO/TW
C
```

```
C:  DETERMINE MAXIMUM RESISTANCE DURING INITIAL (FLEXURAL) PHASE
      QU=MM/(BSS*ZLV*ZLV)
      KS=E*IG/(ASS*ZLV**4)
      YU=QU/KS
      YFAIL0(N)=YFAIL
      KEQ0(N)=KEQ
      QU0(N)=QU
      KS0(N)=KS
      YU0(N)=YU
C Y4 IS DEFLECTION AT INTERSECTION OF EQUILIBRIUM AND SIMPLY
C SUPPORTED RESISTANCE LINES $
      Y4=KEQ*YFAIL/(KEQ+KS)
      Y40(N)=Y4
      IF(ICASE.EQ.1.OR.ICASE.EQ.5)GOTO 280
C
C:  CASES 2,3,4
      Q1=MM/(BF*ZLV*ZLV)
      KF=E*IG/(AF*ZLV**4)
      Y1=Q1/KF
      KEP=(QU-Q1)/(YU-Y1)
      Q10(N)=Q1
      KF0(N)=KF
      Y10(N)=Y1
      KEP0(N)=KEP
      GOTO 280
C
C:  DETERMINE WHETHER BENDING OR EQUILIBRIUM RESISTANCE IS LARGER
C
  280 IF(QU.LE.QEZERO)GOTO 285
C
C:  QU-QEZERO
      Y2=YU
      Q2=QEZERO*(1.0-YU/TW)
      Y20(N)=Y2
      Q20(N)=Q2
      GOTO 295
C
C:  QEZERO-QU
  285 Y2=QEZERO/(KS+KEQ)
      Q2=KS*Y2
      Y20(N)=Y2
      Q20(N)=Q2
  295 CONTINUE
C
C:  MODIFY RESISTANCE VALUES BY APPROPRIATE FACTOR
  310 Q1=Q1*QMULT
      Q2=Q2*QMULT
      QU=QU*QMULT
      KS=KS*QMULT
      KF=KF*QMULT
      KEP=KEP*QMULT
      KEQ=KEQ*QMULT
      Q10(N)=Q1
      Q20(N)=Q2
      QU0(N)=QU
      KS0(N)=KS
      KF0(N)=KF
      KEP0(N)=KEP
      KEQ0(N)=KEQ
C
C:  OUTPUT LOAD-DEFLECTION CURVE
      WRITE(6,901)N
  901 FORMAT(/12H SUBR RESIST/5X,27HLOAD DEFL CURVE   WALL NO.=,I4/)
      IF(ICASE.EQ.1.OR.ICASE.EQ.5)GOTO 320
      WRITE(6,900)Q1,Y1
  900 FORMAT(5X,6HQ1,Y1=,2E12.4)
  320 WRITE(6,902)QU,YU,Q2,Y2,YFAIL
  902 FORMAT(5X,12HQU,YU,Q2,Y2=,4E12.4/11X,6HYFAIL=,E12.4)
  325 RETURN
C
C:  DETERMINE THE RESISTANCE (PER UNIT AREA) OF THE WALL AS
C:  A FUNCTION OF Y
C
C RESISTANCE IS AN ODD FCN OF Y $
C HYSTER=.TRUE. AFTER EDGE HAS CRACKED AND DIRECTION OF MOTION
C REVERSED $
  500 CONTINUE
```

```
      Y2=Y20(N)
      YU=YU0(N)
      ICASE=ICS(N)
      Y4=Y40(N)
      ABY=ABS(Y)
      IF(ABY.GT.Y2)GO TO 520
      IF(ABY.GT.YU)GO TO 502
      HYSTER=.FALSE.
      IF(CRACK(N).AND.REVERS(N))HYSTER=.TRUE.
      IF(HYSTER.AND.(ABY.GT.Y4))GO TO 520
      IF(HYSTER)GO TO 502
      GOTO(502,510,510,510,502,510,510),ICASE
C
C:  ELASTIC: PHASE -- CASE 1
  502 KS=KS0(N)
      Q=Y*KS
  505 ZKLMSE=KLMSE(N)
      VH1S=VH1S0(N)
      VH2S=VH2S0(N)
      VV1S=VV1S0(N)
      VV2S=VV2S0(N)
      ZKLM=ZKLMSE
      VH1=VH1S
      VH2=VH2S
      VV1=VV1S
      VV2=VV2S
      VH10(N)=VH1
      VV10(N)=VV1
      VH20(N)=VH2
      VV20(N)=VV2
      KLM(N)=ZKLM
      RETURN
C
  510 Y1=Y10(N)
      IF(ABY.GT.Y1)GOTO 515
C
C:  ELASTIC PHASE -- CASES 2,3,4
      KF=KF0(N)
      ZKLMFE=KLMFE(N)
      VH1F=VH1F0(N)
      VH2F=VH2F0(N)
      VV1F=VV1F0(N)
      VV2F=VV2F0(N)
      Q=Y*KF
      ZKLM=ZKLMFE
      VH1=VH1F
      VH2=VH2F
      VV1=VV1F
      VV2=VV2F
      VH10(N)=VH1
      VH20(N)=VH2
      VV10(N)=VV1
      VV20(N)=VV2
      KLM(N)=ZKLM
      RETURN
C
C:  *ELASTO-PLASTIC* PHASE (CASES 2,3,4)
  515 KEP=KEP0(N)
      Q1=Q10(N)
      Y1=Y10(N)
      Q=(Q1+KEP*(ABY-Y1))*Y/ABY
C FIRST TIME WALL DEFLECTION .GT. Y1 IT CRACKS AT EDGES $
      IF(CRACK(N))GO TO 516
      CRACK(N)=.TRUE.
  516 CONTINUE
      GOTO 505
C
C:  SECONDARY (EQUILIBRIUM) PHASE
  520 TW=TH(N)
      KEQ=KEQ0(N)
      ZKLMP=KLMP(N)
      VH1P=VH1P0(N)
      VH2P=VH2P0(N)
      VV1P=VV1P0(N)
      VV2P=VV2P0(N)
      IF(ABY.GT.TW)GOTO 525
      Q=KEQ*(TW-ABY)*Y/ABY
```

```
      ZKLM=ZKLMP
      VH1=VH1P
      VH2=VH2P
      VV1=VV1P
      VV2=VV2P
      KLM(N)=ZKLM
      VH10(N)=VH1
      VH20(N)=VH2
      VV10(N)=VV1
      VV20(N)=VV2
      RETURN
C
C:  WALL COLLAPSED -- NO RESISTANCE (TO AVOID DIFFICULTIES
C:  FOR CERTAIN CASES SET RESISTANCE EQUAL TO VERY SMALL VALUE)
  525 Q=1E-10
      RETURN
C END SUBROUTINE RESIST
      END
C
C
C
      SUBROUTINE COEF(ICASE,R,ASS,BSS,AF,BF,I,ZLV,ZLH,PV,NX,CF,
     1E,IENTRY)
C:  THIS SUBROUTINE DETERMINES MOMENT AND DEFLECTION COEFFICIENTS
C:  FOR ONE-WAY (CASES 5-7) AND TWO-WAY (CASES 1-4) WALLS
C
      REAL I,MPR,MPRSQ,NU
C
C CDC MACHINES INITIALIZE VARIABLES TO ZERO $
C THIS IS NECESSARY WHEN ICASE=1 $
C
      AF=0.
      BF=0.
      CF=0.
      IF(IENTRY.EQ.2)GOTO 200
      NX=1
       IF(ICASE.GT.4)GOTO 50
C
       R2=R*R
       R3=R*R2
       R4=R2*R2
       ASS=-.007030+.013890*R-.003456*R2+.000286*R3
       BSS=-.058332+.139314*R-.035609*R2+.003016*R3
    8 GOTO(41,20,30,40),ICASE
C
C:  CASE 2. FIXED ON FOUR SIDES
 20   NX=3
       AF=-.003430+.007327*R-.003365*R2+.0006646*R3-.00004766*R4
       BF=-.101150+.260875*R-.138982*R2+.034677*R3-.004016*R4
     1+.000170*R**5
      CF=-.1674+.3554*R-.1714*R2+.0286*R3
       GOTO 41
C
C:  CASE 3. FIXED ON SHORT SIDES, SIMPLY SUPPORTED ON LONG SIDES
 30    NX=4
      AF=.004513-.017525*R+.023095*R2-.010325*R3+.002187*R4
     1-.0002208*R**5 + .000008408*R**6
      BF=-.122149+.313445*R-.153979*R2+.036192*R3-.004015*R4
     1+.0001646*R**5
      CF=2.1958-7.7564*R+10.8376*R2-7.2495*R3+2.344*R4
     1  -.2954*R**5
       GOTO 41
C
C:  CASE 4. SIMPLY SUPPORTED ON SHORT SIDES, FIXED ON LONG SIDES
 40   NX=3
       AF=-.002765+.008652*R-.005698*R2+.001829*R3-.0002859*R4
     1+.00001739*R**5
       BF=-.060320+.256515*R-.175648*R2+.057928*R3-.009227*R4
     1+.000569*R**5
      CF=5.8987*R-1.6669-7.9398*R2+5.3142*R3-1.7623*R4+.2313*R**5
C
 41   IF(R.GT.2.0)CF=1.0/12.0
      IF(PV.EQ.0)RETURN
      ARATIO=AF/ASS
       BRATIO=BF/BSS
      BFO=BF
      CFO=CF
```

```
            GOTO 220
      C
  50        IF(PV.NE.0)GOTO 300
      C:    CASE 5. ONE-WAY SIMPLY SUPPORTED WALL
            ASS=5.0/384.0
              BSS=0.125
              GOTO(270,270,270,270,270,60,70),ICASE
      C
      C:    CASE 6. ONE-WAY FIXED END WALL
  60          AF=1.0/384.0
              BF=1.0/12.0
            CF=1.0/12.0
            NX=3
            RETURN
      C
      C:    CASE 7. ONE-WAY PROPPED CANTILEVER WALL
  70          AF=1.0/185.0
              BF=0.125
            CF=0.125
            NX=3
            RETURN
      C
  200   IF(ICASE.GT.4)GOTO 300
      C:    DETERMINE ELASTIC DEFLECTION AND MOMENT COEFFICIENT FOR
      C:    TWO-WAY WALL WITH INPLANE FORCES
  220   PI=3.14159165
              NU=0.3
            PE=4.0*PI*PI*E*I/(ZLV*ZLV*(1.0-NU*NU))
              BV=0
  230         AV=0
              PPE=PV/PE
              TERM6=4.0*PI*PI*R*SQRT(PPE)
      C
      C:    SERIES SOLUTION USED TO DETERMINE COEFFICIENTS
              DO 250 M=1,7,2
              MPR=M*PI*R
              MPRSQ=MPR**2
              GMSQ=MPRSQ+2.0*MPR*PI*SQRT(PPE)
              EMSQ=MPRSQ-2.0*MFR*PI*SQRT(PPE)
              TERM5=M*MPRSQ*(MPRSQ-4.0*PI*PI*PPE)
              CSHGM2=0.5*(EXP(0.5*SQRT(GMSQ))+EXP(-0.5*SQRT(GMSQ)))
              IF(EMSQ.LT.0)GOTO 240
              CSHEM2=0.5*(EXP(0.5*SQRT(EMSQ))+EXP(-0.5*SQRT(EMSQ)))
              GOTO 245
  240         CSHEM2=COS(0.5*SQRT(-EMSQ))
  245         AV=AV+(1.0+(EMSQ/CSHGM2-GMSQ/CSHEM2)/(M*TERM6))
           1*(-1)**((M-1)/2)/TERM5
              BV=BV+(MPRSQ+(GMSQ*(NU*EMSQ-MPRSQ)/CSHEM2-EMSQ*(NU*GMSQ
           1 -MPRSQ)/CSHGM2)/(M*TERM6))*(-1)**((M-1)/2)/TERM5
  250         CONTINUE
      C
      C:    CASE 1
            AVSS=AV*(1.0-NU*NU)*R4*4.0/PI
              BVSS=BV*R2*4.0/PI
              IF(ICASE.EQ.1)GOTO 260
      C
      C:    CASES 2, 3, AND 4
            AVF=AVSS*ARATIO
            BVF=BVSS*BRATIO
            CF=CFO*BVF/BFO
  258       AF=AVF
              BF=BVF
  260       ASS=AVSS
              BSS=BVSS
  270       RETURN
      C
      C:    ONE-WAY WALLS
  300       EIPV=E*I/PV
            U=ZLV/SQRT(EIPV)
            U2=0.5*U
            TERM1=1.0/COS(U2)-1.0
      C
      C:    CASE 5. ONE-WAY SIMPLY SUPPORTED WALL
            BSS=TERM1/U**2
            ASS=(BSS-0.125)/U**2
            GOTO(270,270,270,270,270,310,320),ICASE
      C
```

```
C:  CASE 6. ONE-WAY FIXED END WALL
 310  NX=3
      BF=(1.0-U2/TAN(U2))/U**2
      AF=-BF*BSS+ASS
      RETURN
C
C:  CASE 7. ONE-WAY PROPPED CANTILEVER WALL
 320   NX =3
      BF=TAN(U)*(TAN(U2)-U2)/(U*(TAN(U)-U))
      AF=(BF*(0.5+SIN(U2)/TAN(U)-COS(U2))-(SIN(U2)/TAN(U)
     1-COS(U2)-SIN(U2)/SIN(U)+0.125*U*U+1.0)/U**2)/U**2
      RETURN
C END SUBROUTINE COEF
      END
C
C
C
      SUBROUTINE TRANS (B,ZLV,ZLH,ICASE,KRAK,ZKLM,ZKLMSE,ZKLMFE,
     1ZKLMP,VL1S,VL2S,VS1S,VS2S,VL1F,VL2F,VS1F,VS2F,VL1P,VL2P,
     1VS1P,VS2P)
C
C: THIS SUBROUTINE DETERMINES LOAD AND MASS TRANSFORMATION FACTORS
C: AND DYNAMIC REACTION COEFFICIENTS FOR TWO-WAY WALLS.
C
C: DETERMINE LOAD AND MASS TRANSFORMATION FACTORS
C CDC MACHINES INITIALIZE TO ZERO $
C THIS IS NECESSARY FOR ICASE=0 $
      ZKLMFE=0.
      VL1F=0.
      VL2F=0.
      VS1F=0.
      VS2F=0.
      B2=B*B
      B3=B*B2
      B4=B2*B2
      B5=B2*B3
      B6=B3*B3
C
C: CASES 1 =_ 5 -- ELASTIC RANGE
 330  ZKMSE1=20.48*B3*(1./12.-B2/7.5+B3/21+B4/14-B5/18+B6/90)
      ZKMSE2=0.5038-0.7066*B
      ZKLSE1=6.4*B2*(1./6.-B2/10.+B3/30.)
      ZKLSE2=0.64-0.8134*B
      BARS1=B*(1./12.-B2/15.+B3/42.)/(1./6.-B2/10.+B3/30.)
      BARS2=(0.127083-0.184524*B)/(0.4-0.508333*B)
      ZKMSE=ZKMSE1+ZKMSE2
      ZKLSE=ZKLSE1+ZKLSE2
      IF(KRAK.EQ.1)GOTO 335
C: CRACK PATTERN A
      CVS=0.5*B
      CVL=0.5*(1.0-B)
      XP=ZLH*B/3.0
      XBARS=BARS1*ZLH
      ZP=ZLV*(1.0-4.0*B/3.0)/(4.0*(1.0-B))
      ZBARS=BARS2*ZLV
      XBARP=0.5*B*ZLH
      ZBARP=ZLV*(1./24.-B/16.)/(1./8.-B/6.)
      GOTO 338
C: CRACK PATTERN B
 335  CVS=0.5*(1.0-B)
      CVL=0.5*B
      XP=ZLH*(1.0-4.0*B/3.0)/(4.0*(1.0-B))
      XBARS=BARS2*ZLH
      ZP=ZLV*B/3.0
      ZBARS=BARS1*ZLV
      XBARP=ZLH*(1./24.-B/16.)/(1./8.-B/6.)
      ZBARP=0.5*B*ZLV
 338  ZKLMSE=ZKMSE/ZKLSE
      ZKLM=ZKLMSE
      GOTO(390,340,350,360,390,340,470),ICASE
C
C: CASES 2, 3, =_ 4 -- ELASTIC RANGE
  350 IF(KRAK.EQ.1)GOTO 365
      GOTO 340
 360  IF(KRAK.EQ.0)GOTO 365
C: CASES 2A, 2B, 3A, 4B, =_ 6
 340  ZKMFE1=512.0*B5*(1.0/30.-B/10.5+3.*B2/28.-B3/18.+B4/90.)
```

AD-A060 798 SRI INTERNATIONAL MENLO PARK CA F/G 18/3
COLLATERAL AIR BLAST DAMAGE.(U)
APR 78 J R REMPEL, C K WIEHLE DNA001-77-C-0237
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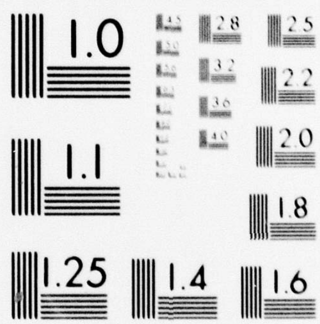

MICROCOPY RESOLUTION TEST CHART

```
      ZKLFE1=32.0*B3*(1./12.-B/10.+B2/30.)
      BARF1=B*(.05-B/15.+B2/42.)/(1./12.-B/10.+B2/30.)
      GOTO(370,365,370,370,370,365),ICASE
C: CASES 2A, 2B, 3B, 4A, =_ 6
 365  ZKMFE2=0.4065-0.6144*B
      ZKLFE2=0.5344-0.7328*B
      BARF2=(.091667-.138095*B)/(.266667-.366667*B)
      GOTO(375,368,375,375,375,368),ICASE
C: CASES 2A =_ 2B
 368  ZKMFE=ZKMFE1+ZKMFE2
      ZKLFE=ZKLFE1+ZKLFE2
      GOTO 380
C:  CASES 3A =_ 4B
 370  ZKMFE=ZKMFE1+ZKMSE2
      ZKLFE=ZKLFE1+ZKLSE2
      GOTO 380
C: CASES 3B, 4A, =_ 6
 375  ZKMFE=ZKMSE1+ZKMFE2
      ZKLFE=ZKLSE1+ZKLFE2
 380  ZKLMFE=ZKMFE/ZKLFE
      ZKLM=ZKLMFE
      GOTO 390
C: CASE 7
 470  ZKLMFE=0.78
C
C: ALL CASES -- PLASTIC RANGE
 390  ZKMP=(1.0-B)/3.0
      ZKLP=0.5-B/3.0
      ZKLMP=ZKMP/ZKLP
C
C
C: DETERMINE DYNAMIC REACTION COEFFICIENTS FOR SHORT (VS) AND
C: LONG (VL) EDGES
C
      IF(ICASE.LT.5)GOTO 395
      XBARS=1E-10
      BARF1=1E-10
      XBARP=1E-10
 395  CONTINUE
      GOTO(450,400,400,420,450,400,445),ICASE
 400  IF(KRAK.EQ.1)GOTO 410
      XBARF=BARF1*ZLH
      IF(ICASE.EQ.3)GOTO 430
 405  ZBARF=BARF2*ZLV
      GOTO 440
 410  XBARF=BARF2*ZLH
      IF(ICASE.EQ.3)GOTO 435
 415  ZBARF=BARF1*ZLV
      GOTO 440
 420  IF(KRAK.EQ.1)GOTO 425
      XBARF=BARS1*ZLH
      GOTO 405
 425  XBARF=BARS2*ZLH
      GOTO 415
 430  ZBARF=BARS2*ZLV
      GOTO 440
 435  ZBARF=BARS1*ZLV
 440  CONTINUE
C
C: CASES 2, 3, 4, =_ 6 -- ELASTIC RANGE
      VS1F=CVS*(1.0-XP/XBARF)
      VS2F=CVS*(XP/XBARF)
      VL1F=CVL*(1.0-ZP/ZBARF)
      VL2F=CVL*(ZP/ZBARF)
      VS1=VS1F
      VL1=VL1F
      GOTO 450
C
C: CASE 7 -- ELASTIC RANGE
 445  VS1F=0
      VS1=0
      VL1F=0.459
      VL1=VL1F
      VL2F=0.165
C
C: CASE 1 =_ 5 -- ELASTIC RANGE
 450  VS1S=CVS*(1.0-XP/XBARS)
```

```
      VS2S=CVS*(XP/XBARS)
      VL1S=CVL*(1.0-ZP/ZBARS)
      VL2S=CVL*(ZP/ZBARS)
      GOTO(455,460,460,460,455,460,460),ICASE
  455 VS1=VS1S
      VL1=VL1S
C
C: ALL CASES -- PLASTIC RANGE
  460 VS1P=CVS*(1.0-XP/XBARP)
      VS2P=CVS*(XP/XBARP)
      VL1P=CVL*(1.0-ZP/ZBARP)
      VL2P=CVL*(ZP/ZBARP)
      RETURN
C END SUBROUTINE TRANS
      END
C
C
C
      SUBROUTINE WINDOW(QMULT,ZLV,ZLH,ZLVW,ZLHW,AWIN,AWALL,R,ICASE)
C
C: THIS SUBROUTINE DETERMINES THE STRUCTURAL
C: MODIFICATION FACTOR FOR WALLS WITH WINDOWS
      IF(ICASE.GT.4.AND.ICASE.NE.10)GOTO 320
      RWWS=ZLVW/ZLV
      RWWL=ZLHW/ZLH
      RAREA=AWIN/AWALL
      IF(R.LE.1.5)GOTO 300
      IF(RWWS.GT.0.7)GOTO 300
      IF(RWWL.LT.0.5)GOTO 300
      IF(RWWS.EQ.RWWL)GOTO 300
C
C:   CASE WHERE LV/LH ¬= 1.5, LVW/LV ◆= 0.7, AND LHW/LH ¬= 0.5
C:   (BUT LVW/LV NOT EQUAL TO LHW/LH)
      QMULT=-5.85461-12.6644*RAREA+4.39662*RWWS+0.84843*RWWL
     1-0.223*R-1.07269*(ZLVW/ZLHW)**0.9+6.59942*EXP(RAREA)
      GOTO 315
C
C:   CASE WHERE ONE OR MORE OF ABOVE CONDITIONS IS NOT MET
  300 QMULT=0.62022-2.23415*RAREA**(RWWL**4)-0.79461*RWWL**2
     I-2.27663*RWWL+0.62522*RWWL/RAREA**0.3
     1+2.63043*EXP(RAREA)-0.09268*RWWS
  315 CONTINUE
      RETURN
C
C ONE-WAY ACTION WALLS
  320 QMULT=(AWALL-ZLV*ZLHW)/(AWALL-AWIN)
      RETURN
      END
C END SUBROUTINE WINDOW
```

Appendix

NOMENCLATURE

(FORTRAN variables not included)

a, b, α, β	Numerical factors used in definition of blast wave shape (functions of p_{so})
A_w	Area of opening
c	Sound speed
C_d	Drag coefficient of object or wall in blast wave
K	Discharge coefficient
L	Length of a wall
M	Mass
n	Integer
p	Stagnation or quasisteady pressure
p_1	Pressure outside an opening (absolute)
p_3	Room pressure (absolute)
p_{crit}	Critical value of ratio p_3/p_1; determines existence of choking
p_d	Dynamic pressure
p_{do}	Peak free-field dynamic pressure
p_o	Ambient pressure
p_r	Peak reflected overpressure
p_{so}	Peak free-field side-on overpressure
q_2	Maximum equilibrium phase wall resistance
q_o	Value of equilibrium wall resistance at zero deflection
q_u	Ultimate elastic wall resistance

R	Gas constant
t	Time
T	Ambient temperature
t_c	Clearing time of a building elevation or exterior wall panel
t_o	Duration of positive overpressure behind a blast front
t_{o1}	Positive overpressure phase duration when explosive yield is 1 kt (4.184 TJ)
t_u	Duration of positive dynamic pressure
U	Free-field shock velocity
V_R	Volume of room
W	Explosive yield, internal energy of air
y_2, y_u	Wall deflections corresponding to q_2, q_u
y_c	Wall deflection
y_f	Wall deflection corresponding to zero equilibrium resistance
γ	Ratio of specific heats (γ = 1.4 for air)
ρ_1	Air density outside opening
ρ_3	Air density inside room

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